

FAO FISHERIES BULLETIN

Volume IX, Number 4

October-December 1956

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Reprints of feature articles are available from FAO Headquarters, Rome, Italy.

Printed in Italy

ROTTERDAM MEETING OF FISH PROCESSING TECHNOLOGISTS



CURRENT TECHNOLOGICAL PROBLEMS IN FISH CANNING*

Introduction

This report will adhere strictly to the limited field indicated in the title, i.e., those problems which are specific and characteristic of the fish canning industry. It will deal primarily with the raw material (fish, mollusks and crustaceans), its handling and preparation, the container/contents relationships, the fish canning operations and the effect of heat processing and of storage upon the quality of canned fisheries products.

It must be stated, nevertheless, that many fish canners and research workers in this field consider solution to such problems as external corrosion of the cans among the most important technological tasks to be undertaken.

I. Quality

The fish canning industry endeavors to produce canned food not only acceptable to the widest circle of consumers, but which may be chosen in preference to other competing animal protein foods.

Consumer acceptability is, and may perhaps always be, determined by subjective, organoleptic tests. The consumer judges the quality of the product by its appearance, odor, flavor, texture and general workmanship.

The factors which influence the quality criteria are mainly: the raw material; its freshness and natural qualities; the methods of handling, preparing, pretreating and of packing the raw material in cans; the effects on the can contents of heat sterilization and subsequent cooling; the chemical interaction between container and contents; and the effects of storage conditions on containers and contents during more or less prolonged storage. It is on the control of these factors that the technological problems in fish canning are focussed.

II. Raw Material

It is axiomatic that the quality of the canned product depends primarily upon the quality of the raw material delivered to the cannery and the conditions under which it is held there prior to canning, and yet this is still the most important problem facing the fish canning industry. With it is intimately related the prob-

* By Dr. E. Hess, Chief, Technology Branch, Fisheries Division, FAO, Rome. Paper presented at the 3rd International Canning Congress, 24-29 September 1956, Rome, Italy.

lem of assessing the quality of the raw material, i.e., the need for objective methods of grading the raw material as a routine cannery procedure.

The quality of the raw material, apart from any physical damage it may have suffered from rough handling, depends upon two main factors :

(a) The *natural characteristics* of the fish flesh which may vary with season, spawning conditions, molting conditions in the case of crustaceans, age, fishing grounds, etc., and which influence especially the fat (and inversely the water) content of the flesh, the degree of saturation of the fatty acids present in the fatty fish, and the flavor of the flesh.

In South Africa, when canning pilchards it is occasionally observed that the fish have partly or completely disintegrated during processing. This "mushiness" can be ascribed to various causes. If the fish are caught during the spawning period, they pass out of rigor very quickly, and turn soft and flabby immediately. The most troublesome cause is the infestation of the somatic muscle of the fish with a proteolytic protozoan parasite (*Chloromyxum chrysitis*) which cannot be recognized in the fresh raw state of the muscle. Such fish are most difficult to eliminate at the packing table, and current work is aimed at developing objective physical or mechanical methods of eliminating fish unsuitable for canning (34).

The type and amount of feed present in the intestinal tract at time of catching may be a primary factor in determining the suitability of the raw material for canning. This can be controlled by allowing the live fish, mollusks or crustaceans to starve, in order to empty their intestines. This has long been the practice in the canning of sardines, sprats, herrings, clams, oysters, etc. Recent work has also shown that, in the canning of rock lobsters, the canned flesh (tail) was appreciably whiter in color and had a stronger and sweeter flavor when the crawfish had been starved for two days before canning than when they were canned immediately after catching (27). In Norway, brisling may not be canned until their fat content (as determined by official chemical analysis) has reached 7%. Similarly, fish unsuitable for canning, e.g. immediately after spawning or molting (crustaceans), when containing toxic feed (e.g. Gonyolax, in clams and mussels), are excluded from utilization in canneries by proper cannery quality control or by government regulations and control.

(b) The *freshness* of the raw material. Deterioration begins with death, even in the death struggle during catching. In tuna, it has been found that the body temperature rises by almost 21° F. (12° C.) within 50 minutes after death (65).

The spoilage proceeds at a more or less rapid rate, depending primarily upon the temperature of the flesh, as this in turn influences the rate of growth, reproduction and enzyme activity of the

spoilage bacteria always present on the raw material, as well as the rate of chemical changes leading to rancidity in the fatty fishes. It will be apparent in the following sections, that the freshness of the raw material — or lack of it — may have effects not only on the flavor of the canned product, but also on its color and texture.

Handling of Raw Material

Bleeding. The methods of handling and preparation of fish for canning not only influence the keeping quality of the raw material, but have also a pronounced effect upon its color, texture and flavor. In the handling of freshly caught tuna, for example, exact procedures are prescribed in many countries, such as Denmark, France and Norway, calling for the proper bleeding through the performance of prescribed cuts, as soon as the fish are hauled aboard, and for the removal of the gills and heart. In Norway, unbled tuna are excluded from export.

Gutting. As with draining off the blood, the removal of the intestines means the removal of the heaviest source of bacterial contamination. Ceylonese tests confirm that fish gutted as soon as brought aboard are superior to those transported "round" and gutted after landing under similar conditions of icing aboard (44).

Keeping Quality

Chilling. Since fish are among the most perishable foods, the problems of keeping the raw material fresh from the time of catching to the time of canning are especially acute; mollusks and crustaceans such as lobsters must, in fact, be kept alive until the actual canning process begins. Refinements in the holding of fish in crushed ice are being investigated. The use of ice of smaller sizes (flake ice, scale ice, etc.) has shown that the more intimate contact of ice and fish surfaces increases the cooling rate of the fish and thus prolongs the keeping quality. The use of sea water ice is claimed to give even better results, due to its low melting point.

In a recent FAO Meeting of Fish Processing Technologists, (Rotterdam, 25 to 29 June 1956) (see pp. 200-201), the problems of chilling fish received special attention. Information presented showed that the use of chilled sea water or weak brine for holding freshly caught fish aboard fishing and transport vessels (e.g., in the salmon canning industry of British Columbia, Canada), and in the canneries themselves (e.g., pilchard and mackerel canneries on the Pacific Coast of the U.S.A.), is receiving increased attention due to the advantages of this method over the standard methods of holding fish in crushed ice.

In Yugoslavia, recent tests have shown that sardines, if chilled within two to three hours after catching, could be held up to three days before canning, whether packed in finely crushed ice or held

in refrigerated sea water (46). South African workers found that it is more economical in capital costs to use water and ice for chilling pilchards than to circulate mechanically refrigerated water through the fish holding tank, especially during peak periods (25).

Another line of attack lies in the use of antibiotics, either incorporated into the ice used for chilling fish or used in chilled brines for short dips or for longer storage. In a special symposium, the above-mentioned FAO meeting dealt with the effects of the use of antibiotics on fresh fish. Among the most effective antibiotics are oxytetracycline and chlortetracycline (aureomycin). While most effective in treating fish fillets, they have been found of great value also with gutted fish. Dips lasting one-half to two minutes in concentrations of 10 to 25 p.p.m. antibiotic in weak brine, doubled and trebled the keeping quality of the fish at ice temperatures. Use of 5 p.p.m. in ice and use of 1 to 5 p.p.m. in chilled brine storage were equally effective. It has been demonstrated that any traces of the antibiotics remaining before consumption are destroyed by the ordinary cooking processes. It should be pointed out, however, that the use of antibiotics in any country still awaits approval.

While *rock lobster tails* may be held at 32° F. (0° C.) up to 42 hours, tests to determine the keeping quality of raw and cooked tails, showed that the former were superior whether held at 32° F. or at room temperature. Holding cooked tails (in the shell) in iced sea water for 24 and 48 hours before canning caused a loss of flavor, pinkish discoloration of the white flesh and softer texture and lower drained weight in the canned product. Cooked tails held 42 hours at 32° F. showed blue discoloration of the meat after canning. Raw tails kept 48 hours at 32° F., were better than whole raw rock lobsters (55, 63).

Freezing. Where distances from fishing grounds to canneries are great (i.e., in the tuna industry in the Pacific Ocean), or where it is desirable to keep the raw material over a period of weeks, to take care of seasonal peak catches, the freezing of the raw material has a special importance. This applies especially to tuna, salmon, sardines, sprats and rock lobsters. The problems involve mainly the effect of brine freezing and the method of thawing upon the salt content of the canned product, and the effects of length of storage and storage temperature on the frozen raw material on the quality of the final canned product.

In *salmon* canning it has been found that the amount of salt carried in the canned product depends on the methods of storing brine frozen salmon (red salmon), and on the method of thawing. The salmon are usually either brine frozen and held in refrigerated brine at 5° F. (-15° C.) up to two weeks until arrival at the cannery, or they are brine frozen in the brine wells in the boats (12 hours at 5° F.), and then stored at 5° F. in dry refrigerated storage. Tests showed that after thawing in running water, or in still water or in still air (12 to 24 hours), there was practically no difference

between the salt content of the canned salmon after several months of storage, and the commercial packs from unfrozen salmon. The fish frozen and held in refrigerated brine for two weeks and then thawed in running water carried less than 0.5% salt in the canned product. This can easily be compensated by adding only half the usual amount of salt to the cans (57).

It is recommended that salmon should be rapidly frozen, preferably before rigor sets in, be well glazed and stored at 0° F. (-18° C.) for not more than two to three months. As freezing causes protein denaturation, this may lead to increased curd formation and a rather tough, dry texture of the canned product (69). Tests have shown that to some extent this can be reduced by brining the cut sections of the thawed fish, e.g., immersion for 10 minutes in 70° salinometer brine in case of coho salmon (5). To prevent curd formation, Canadian workers found dips of the raw fish in a dilute solution of harmless acids fairly effective. Phosphoric dips resulted in the best appearance, tartaric acid dips in the best flavor in the canned product, but all acid-treated raw material caused objectionable reaction on the tin plate (73).

In recent years much attention has been paid to the freezing of *sardines*, *sprats* and *small herrings* for subsequent canning. Norwegian tests showed that fat and lean brisling (*Clupea sprattus*) may be kept frozen at -31° F. (-35° C.) for 11 to 13 weeks before canning. Canned samples were of comparable quality to those made from fresh fish. Winter-caught herring containing high amounts of trimethylamine oxide did not thaw satisfactorily. Small herrings easily dropped from the hooks during smoking prior to canning. When frozen sprats were held at temperatures higher than -10° F. (-23° C.), the quality of the canned product was inferior. To be of practical value the frozen fish should be able to stand at least eight weeks frozen storage (7, 48).

Yugoslav experiments showed that sardines can be kept up to one month at -4° F. (-20° C.), if chilled in ice within two to three hours after catching and frozen within 24 hours. For storage up to one month, glazing was not important, but beyond this glazed frozen sardines resulted in a better canned product. Brine frozen fish were less acceptable, after canning, than air frozen ones (23). North African frozen sardines have in recent years been shipped to canneries in Metropolitan France, but have not resulted in as acceptable a product as canned fresh sardines.

Rock lobster tails may also be frozen for later canning. They should be de-veined before freezing. Thawing in tepid water to which some vinegar has been added is said to give the best results. The fully thawed tails are cooked, shelled and canned in the same way as the unfrozen tails (21).

The freezing of *tuna* is no doubt the most important and best established practice of using frozen raw material for canning fish, whether it be frozen aboard the Pacific tuna clippers which frequent fishing grounds long distances from the shore canneries, or

whether the fish be landed from nearby fishing grounds and frozen ashore for long distance export shipment, such as the Norwegian tuna fishery providing Italian canneries with frozen raw material. In California, (U.S.A.), there is general agreement that the most important problem in the tuna canning industry is the quality of the fish delivered to the cannery. The three main technological problems pertain to handling and freezing aboard the tuna clippers, namely :

- (a) more rapid handling aboard before refrigeration becomes effective ;
- (b) improvement in refrigeration technique to preserve the fish flesh in its original condition as much as possible, and
- (c) to store the fish aboard so that they suffer the minimum damage during unloading (23).

The ideal procedure is said to be to chill the fish first in cold sea water, followed by further cooling and freezing in strong, refrigerated brine.

Difficulties arise when fishing is poor and a long time is taken to fill up a brine well with fish. Then there is a considerable time lag before the brine can be drawn off and coil refrigeration used. Again, when catches are big and the refrigeration capacity of the boat becomes overloaded, the freezing rate is reduced. Difficulties also arise when there are delays in freezing because some of the tanks are temporarily used for holding live bait or fuel.

U.S. tests have shown that tuna may be held at -4°F. (-20°C.), for 15 months, provided the fish are dipped in chilled brine before freezing and are defrosted in cold water. Freezing in brine or water instead of air freezing prevents browning of the hemoglobin on thawing (8). Little tuna (*Euthynnus alleteratus*) may be kept at 0°F. (-18°C.) up to three months without deterioration of quality, but are unfit for canning after six months storage. Freezing these fish round proved better than freezing the gutted fish, which resulted in darkening of the flesh of the body cavity and in strong flavor. Storage at 10°F. (-12.2°C.) resulted in poor color, odor and flavor of the canned product (42).

Effects of Pre-treatment of Raw Material

Color. The old adage that the consumer is more influenced in his purchases by his eyes than his palate, emphasizes the importance of color in the canned product. The problem is twofold : it is either a question of preserving the natural original color of the flesh, or one of producing a more acceptable color. The latter case applies especially to tuna, some species (e.g., blue fin tuna) having a flesh with a rather dark natural color which, after canning, is less acceptable than that of light colored "white meat" tuna, such as

albacore. Attempts to treat tuna meat by means of harmless bleaching agents have been made in many parts of the world, but even the most promising agents give an undesirable flavor.

The problem of preserving the natural color has also two phases. For example, in salmon the problem is one of the occasional fading of the desirable natural red color during processing and the difficulty of predicting this occurrence. As in some varieties, the final color of the canned product has no consistent relation to the fresh color, it is most difficult to sort the raw salmon on a color basis prior to canning. Canadian workers have developed a rapid test to predict color behavior; slices of raw flesh when dipped into glycerin at 435° F. (224° C.), show a similar color change to that caused by processing. Fading can be prevented by short dips in sodium nitrite solution (73).

Research undertaken at the University of Hawaii and in California (U.S.A.) is attempting to find the causes and possible remedies for the occasional occurrence of "green" canned tuna. This change is not predictable from the appearance of the raw flesh; the green-brownish color and off-odors appear only after the meat is cooked (74).

The other problem is the reverse, i.e. the prevention of a darkening of the natural white or light color of the flesh, especially in the case of canned crustaceans. Dilute organic acids have often been found effective. The treatment of rock lobster tails with diluted citric acid before canning resulted in a slight improvement in color after canning, without effecting the texture or flavor (15).

Flavor. The flavor of the canned product may be directly affected in the preparation and pretreatment of the fish. Most important is the influence of salt. While the purposes of salting raw fish may be manifold (e.g., to remove blood and slime as in brine immersion, to make the flesh firmer and "bring out" its characteristic flavor), the ultimate effect is on flavor. Extensive tests by South African workers (64) on canned pilchards have emphasized the problem of obtaining a uniform salt content in the final product in all circumstances. A content of 1.1 to 1.6% salt is considered the most desirable. If salting is done through brining, it is difficult to give all pieces of fish a uniform length of immersion. Obviously the brine strength and length of brining are inversely related. To obtain 1.5% salt in the canned pilchard, brining was required for 30 minutes with a 26.3% brine and, successively, 60 minutes (18% brine); 4 hours (9.2%); over 8 hours (7.5%). Similarly, the ratio of brine to fish immersed and period of brining are inversely related. To reach the 1.5% salt content, 2 hours brining in 10% salt brine was sufficient if the ratio brine: fish was 5:1; and, successively, ratio 2:1 (4 hours); 1:1 (8 hours). Expressed differently, 8 hours brining resulted in a salt content of 1% if the ratio 1:1 was maintained; of 1.3% with a ratio brine: fish 2:1, and of 2% with a ratio 5:1. From 25 to 30% of the absorbed salt may subsequently be lost when the fish are precooked and drained. If the salt is added in the form of hot brine, after the

precooked fish have been drained, it is equally difficult to add uniform amounts. Under commercial conditions the authors found variations from 0.83 to 1.56% salt in No. 1 tall cans, and from 1.01 to 1.35% salt in oval cans.

When salt pellets were added before precooking and draining, there was a subsequent loss of up to 50% of the added salt. Pellets, added to the already filled cans, frequently rolled off. They usually dissolve during processing and the can contents are uniformly flavored after about three days.

When sea water was used in making the brine, the canned pilchard acquired not only a slightly saltier but also a somewhat unpleasant flavor, no doubt due to salts other than sodium chloride occurring in sea water (1).

Recent experiments on the canning of sardines in Morocco (52) confirmed that the salt content of the canned product, due to preliminary brining, depends on the strength of the brine, its temperature and the period of brining. From 40 to 60% of the salt absorbed during brining was lost in subsequent precooking.

The addition of monosodiumglutamate in the canning of tuna (3) and clams — concentration 0.1% in the final product — has yielded products with improved flavor (4).

Smoking has long been used as a means of improving the flavor of canned fish. Electrostatic smoking has been developed in several countries (Canada, Western Germany, U.K., U.S.A). Sardines are transported on endless wire belts which are grounded. The positively charged smoke particles are deposited on the fish in a matter of seconds (11). Split salmon are smoked similarly, thus reducing the smoking time from several hours to eight minutes (14).

Texture. The texture of the finished canned product is largely dependent on the water content of the raw material before processing. Relatively few types of fish can be canned raw, i.e., without precooking or predrying, and yield a satisfactory product. The few exceptions are salmon, mackerel packed salmon-style, and tuna. The consumer prefers the can contents to consist of firm meat with a minimum amount of watery liquid. Due to the heating and cooking which raw can contents undergo during processing, the fish flesh proteins coagulate and lose moisture, the amount of liberated water being proportional to the moisture content of the raw material. To avoid liberation of liquid in the can, the moisture content of the raw material should be adequately reduced before the can is closed and processed. This is achieved by precooking and/or predrying the fish, either before they are placed in the cans, or after the can is filled, but before it is sealed, having allowed the cooked-out liquid to drain off first. The use of infrared heat to precook sardines has been introduced commercially.

The so-called lean fish, e.g., the cod family, containing some 80% water, are not generally canned, except in the form of precooked "fish flakes" or fish cakes and fish puddings. But even the slightly fatty fish need reduction of their water content to

about 60% by means of precooking to avoid soft, soggy or even mushy consistency of the final product. It is recognized that the sum of water plus fat in the raw flesh is fairly constant for most species, the seasonal increases and decreases in fat content being accompanied by the reverse changes in the water content.

Moroccan experiments (52) have shown that fat *sardines*, containing less water, require less cooking than lean ones. Steam cooking at 212° F. (100° C.) of the raw (brined) fish causes a loss of 19 to 34% in weight.

The presence of water (in excess of 1 cc. per Club 30 can) in the can liquid, after processing, indicates insufficient precooking or drying (or too high a processing temperature). With adequately steam-cooked sardines, additional hot air drying was not of much benefit. The more water lost during cooking, the more oil will be absorbed during processing. Excessive drying, on the other hand, caused the consistency of the can contents to become "woody" and decreased the oil absorbing faculty of the dried fish flesh. Tests showed that the added oil and the oil of the flesh came to an equilibrium within a few days after processing — canned tuna is said to require three months' storage for even distribution of oil and salt (53).

Similarly, when canning clupeoid fish in tomato sauce, the correctness of the precooking time (shorter than for sardines in oil) can be recognized in the finished product by the consistency of the sauce, i.e., with insufficient precooking the sauce becomes watery, with overcooking some of the sauce is absorbed into the flesh. Lean sardines will absorb up to 50% of the oil usually mixed with the tomato sauce (52).

A number of continuous cookers, already established in commercial canning operations in several countries, have been developed in recent years to mechanize the precooking of sardines and similar products, after they are packed into the cans. The process is to drain the inverted cans and dry the can contents in a current of hot air, before the oil or sauce is added and the cans sealed (43).

In the canning of *mackerel fillets* (in oil), Danish tests (59) have shown that the precooking should also be well controlled. If the fillets were canned raw, the resulting product showed a tough texture and a brownish-grey darkening of the flesh, especially if the loss of water during subsequent processing exceeded 20%. In order to reduce the water content of the fillets to about 66%, precooking of the fillets in water for 15 to 20 minutes or in 212° F. steam for 20 to 30 minutes is necessary, followed by cooling in a dry cool place.

South African *stockfish* (67) require 40 minutes at 212° F. to give the best results (white color, firm texture and good flavor). Excessive length of precook (e.g., two hours at 212° F.) results in as much as 26.5% shrinkage, too dry a consistency and sticking of the contents to the can. Excessive precook temperature, e.g., 240° F. (115° C.), results in brown discoloration of the flesh.

South African *snoek* (54), on the other hand, benefit by prolonged (two hours) precooking which is said to impart a desirable caramel flavor to the final canned product.

The precooking of *tuna* varies greatly according to species and country. In France (31), cooking of the flesh, cut into 4 to 5 lb. (1.8 to 2.3 kg.) pieces, wrapped in paper, in 16° salinometer brine for two hours, is said to give more satisfactory results than steam or hot air cooking. Experiments in the U.S.A. (42) with little tuna (*Euthynnus alleteratus*) gave best results with steam cooking at 216° to 221° F. (102° to 105° C.) for 90 minutes for fish up to 10 lb. (4.5 kg.), 120 minutes for 12 to 15 lb. (5.4. to 6.8 kg.) and 150 minutes for larger fish. In Italy (22), frozen tuna are washed in weak brine after thawing and cooked in 7 to 15% brine for 90 minutes or pressure cooked at 260° F. (126° C.) for 20 minutes.

Norwegian tests (48) to tenderize the somewhat coarser flesh of blue fin tuna by means of treatment with proteolytic enzymes have proved unsatisfactory; although the canned flesh became tenderer, the texture became granular and the flavor changed.

An improvement in texture of the canned product (herring, anchovy, tuna, etc.) has been obtained by Canadian workers (73) by a 20-minute vacuum drying treatment of the precooked fish with simultaneous rapid cooling from the cooking temperature to 60° F. (15.6° C.). It is expected that such treatment will at the same time remove undesirable volatile substances from the raw material.

Chemical treatment of fish with a "water binding agent," such as a 5-minute dip in a solution of CMC (sodium salt of carboxy-methyl-cellulose), between the brining and processing steps, is said to be successful with herring packed in oil or tomato sauce, making precooking unnecessary (66).

For objective measuring of the texture, the "penetrometer" has been successfully developed. The head of the instrument drops vertically into the open can; depth of penetration is read off directly on a millimeter scale. Four replicate tests are desirable for ½ lb. (227 g.) flat cans. It is proved that the texture of frozen Pacific salmon is firmer after canning than that of fresh salmon (35).

III. Effects of Heat Processing on the Quality of Canned Fish Products

It is not proposed to deal here with sterilization, but merely with the effects of the heating on the physical and chemical characteristics of the can contents during retorting. Excessive heat processing in the retort will cause increased shrinkage, i.e., a decrease in the drained weight of the can contents, and may cause the chemical breakdown of some of the ingredients of the fish flesh, such as trimethylamine oxide, and the chemical changes characteristic of the Maillard sugar/protein reaction (72), resulting in a brownish discoloration of the white flesh.

In fish canning it is still one of the major problems to find practical methods of preventing "seorch." The technological problems involved are: the determination of the optimum time/temperature relation of processing; strict, preferably automatic, retort control; keeping recording thermometer records, and increased attention to proper, rapid cooling procedures.

South African workers (28) propose the official enforcement of exact processing control specifications, including processing time and temperature standards and can seam specifications.

In the canning of some types of fisheries products, e.g., lobsters, a reduction of the processing time, and thereby of the undesirable heating effects on the color and flavor of the lobster meat, can be achieved by means of increasing the ratio of liquid (brine): solid (lobster meat), thus increasing the rate of heat penetration into the can. Recent Canadian tests (33) have confirmed this.

Tests with canned rock lobster (45) have shown that it takes only 27 minutes to cool the center of an 8 oz. (227 g.) can from 200° F. (93° C.) to 100° F. (38° C.) with running water at 75° F. (24° C.), but 45 minutes in an air blast of 400 ft./min. (122 m./min.) and 150 minutes in still air at 75° F. (23.8° C.). Brown discoloration of crab meat can also be avoided by rapid (water) cooling of the processed cans (32).

Together with the introduction of automatic retort control, increased attention is being paid to automatic, rapid cooling of the processed cans under pressure.

IV. Effects of Storage on Quality of Canned Fish Products

Some of the effects referred to previously (which may be caused by the nature of the raw material, its preparation, pretreatment, heat processing, etc.), become evident immediately after processing and cooling of the cans, but many of the changes are apparent only after storage of the canned goods. As with all chemical reactions, the rate of change depends primarily on the storage temperature.

In a recent article, Ball (19) called *high storage temperature* the "universal leveler" of quality of canned foods, which soon reduces original differences among different quality grades insofar as flavor, color and texture are concerned. He advocates that the sterilizing process should be so modified as to retain the natural characteristics of the food unimpaired (short, high temperature processing), provided this quality is maintained by adequate low storage temperature of the canned food. The relative storage costs at ordinary (room) temperature are estimated at 1 U.S. cent/lb. per year, as compared with 2 cents for storage at 32° to 36° F. (0° to 2.2° C.), and 3 cents at 0° to 15° F. (-18° to -26° C.).

Discoloration

Here, the formation of colored substances (usually inorganic), which are produced through chemical reaction between natural constituents of the fish flesh among themselves or through chemical reactions between can contents and containers, are dealt with.

The most critical element in this respect is iron, whether the source be the container itself, the raw material, or extraneous (cannery equipment, water supply, etc.). Its reaction with free sulphide (e.g., H_2S) leads to the formation of iron sulphide which, if occurring in canned food, causes unsightly discoloration ranging from blue to black.

The problem of iron sulphide discoloration in canned fish is still a "current technological problem," despite the tremendous amount of research and development work that has been devoted to it during the last 60 years. The first paper on the subject, dealing with the formation of iron sulphide in Canadian canned lobster, was published in 1897 (47, MacPhail and Bruère), other major contributions being made later by Harrison (38) and Reed (62).

The new container materials with less protective tin (electrolytic tin plate, lacquered tin plate, etc.), have created new problems in this respect. Norwegian experiments (49) have shown that ordinary electrolytic tin plate, unless extra heavily tinned, is unsuitable for canning fishballs, even $1\frac{1}{4}$ lb. (0.56 kg.) tin per base box leading to blackening in the cans. However, lacquered electrolytic tin plate, with only $\frac{3}{4}$ lb. (0.34 kg.) tin per base box, was found satisfactory for canning tuna in oil and mackerel in bouillon, as well as shrimps and crab meat, provided a paper lining was used for crustacean packs.

In some cases it is the high iron content of the fish flesh itself (e.g., abalone) which creates the problem (55). While acidification of the can contents (0.5% citric acid by weight) was found to inhibit the iron sulphide discoloration, this amount of acid made the can contents unpalatable and a practical solution has still to be found.

In other instances, it is the rapid spoilage of the raw material with liberation of free sulphide that presents the difficulty as with crustacean meat (lobsters, shrimps, crabs) and young eels (15). The use of only perfectly fresh raw material, rapid handling, packing in C-enamel cans, preferably with parchment lining, are some of the safety measures. Eels are also cooked in acidified brine. It is well known that iron sulphide formation is reduced at an acid pH. In crab meat, development of over 20 mg. volatile basic nitrogen per 100 g. meat as an indication of spoilage, causes blue discoloration in the canned product (71). Dipping of crab meat in solutions of weak organic acids or their salt (citric, lactic, acetic, etc.) is also being recommended (30, 36) as it was some 30 years ago by Harrison (38) for canning lobster meat.

Acid dips of rock lobster tails (5 minutes in an excess of 0.3% citric acid) have also been found effective in considerably reducing the occurrence of "storage odor" in old cans (stored up to 61 weeks) (56).

The introduction of the protective C-enamel, based on the principle of substitution of zinc for iron, to induce formation of zinc sulphide instead of unsightly, black iron sulphide, has meant tremendous progress in the canning of protein foods, although it may not have solved one of the basic problems, i.e. of overcoming deterioration of the raw material through better and quicker handling and preservation before canning. The appearance of iron sulphide is often an indicator of spoilage through the liberation of free sulphides.

Complete enamel protection in cans with side seams will shortly be provided, according to Swedish workers, by means of applying an inside strip of lacquer along the side seam.

This old problem of ferrous iron sulphide formation is currently receiving especial attention in the U.S.A. in the canning of tuna. It is found to occur sporadically, for unknown reasons, in solid pack, but not in grated or flaked-style pack tuna. The discoloration usually appears on the inside surface of the cover, in the headspace area of the container. It may suddenly appear in the whole batch within 24 hours of processing (24). Non-sulphide sulphur is transformed to free sulphide (H_2S) during spoilage due to slow freezing (overloading of refrigeration facilities in tuna clippers), or delays in handling. On the other hand, it is claimed that all sulphide sulphur is driven off during an even short precooking and it is assumed that the free sulphides are formed during the retorting (12), possibly as a result of over-processing. While some workers believe the pH of the can contents to be an important factor, others have found no correlation. To decrease the amount of iron exposure in the cans, improvements in the inside enamel are being tested. A double enamel is being used, the second coating containing 15% zinc oxide (60).

A bluish-greenish color is caused in canned crustaceans by the formation of cupric sulphide, the copper originating from the blood of the species (crabs, lobsters, rock lobsters). It is interesting to note, however, that while proper bleeding of the live crabs was found to prevent such discoloration of the canned product (30), the bleeding of rock lobsters is said to have no such beneficial effects (45).

Curd formation. While coagulated blood in badly washed canned crustacean meat may cause discoloration, the "curd" appearing in packs of salmon and mackerel (species generally canned without precooking) is of a different origin. The flesh contains certain amounts of water — and brine-soluble, heat-coagulable proteins, which are cooked out of the flesh during processing and coagulate in unsightly lumps. Japanese tests (70) have shown that if mackerel cuts are soaked in 10 to 15% brine for 30 min-

utes, then washed in fresh water, a maximum of these substances is effectively removed and curd formation prevented.

Formation of struvite crystals. The formation of magnesium-ammonium-phosphate crystals is especially, but not exclusively, prone to occur in canned crustaceans (lobster, crawfish, crab). Earlier Canadian research work established that the magnesium is the limiting factor and that sea water, whether used in washing the lobster meat or in making brine to be added to the can, is a major source (40). The importance of pH was also demonstrated, as the crystals are acid soluble below pH 6.5. These findings have been confirmed for South African crawfish (rock lobster). Treatment with lactic acid gave better results than citric acid dips (26), but neither were considered desirable. Leaching the flesh in acidified water to remove the natural magnesium content also tended to prevent crystal formation (45). The addition of 0.5% sodiumhexametaphosphate as a sequestering agent was found effective too, although, being rather insoluble, its addition in solution presented difficulties. It is an almost neutral salt, with little or no taste, which can also be added dry. It is said to be safe, and low in cost, only small amounts being required. In the presence of sodium chloride it will hold three times as much struvite in solution as will fish broth (51).

V. New Products

The development of new and special canned fish products with the object of utilizing to the best advantage new types of raw materials as well as to widen markets, is always a challenge to the industry.

This may take the form of using canning as a new method of preservation for a particular species, such as sharks (37), eels (20), sturgeon (6), carp (61), or canning prepared dishes in which salmon (10) or tuna (50) are used as a base, or canning fish chowders (66). The testing of new recipes, suitable for canning, opens a wide field of development for speciality products.

A special field is the preparation of dietetic packs, e.g. salmon packed without the addition of salt. Research into the normal salt content of the 5 pacific salmon species caught in different districts and at different seasons is necessary, to avoid labeling difficulties, i.e., understatements as to salt content. About 25% of the total sodium and phosphorus content of canned Pacific salmon and tuna (albacore) is found in the can liquid, 73 to 74% in the flesh, and 3 to 4% in the bones. While practically no difference was found in the phosphorus content of commercial and dietetic packs (240 to 365 mg. phosphorus per 100 g. can contents), the sodium content of the dietetic packs was only 4.5 to 9% of that of the commercial packs, but did contain some 30 to 60 mg. sodium per 100 g. can contents (58).

VI. Engineering Problems

The engineering problems in fish canning fall into two main categories :

- (a) the mechanization of procedures through development and introduction of new or improved equipment, and
- (b) the use of new materials in the construction of cannery equipment to eliminate all danger of metallic trace elements contaminating the fish flesh.

The introduction of stainless steel equipment in the canning of crustaceans and mollusks, of eels and fishcakes, has greatly improved the possibilities of packing high quality products. This applies especially to washers, cookers, pipes, pumps and working surfaces (16).

In the canning of shrimps in the U.S.A., stainless steel weighing and carrying baskets, flumes, picking tables, hoppers, Monel metal steam coils, nickel brine and blanching tanks and brine pipes, collection hoppers and packing tables of 18% chromium — 8% nickel stainless steel alloys are being introduced to eliminate iron and copper contamination of the shrimp meat.

The tendency, generally, is towards automatic handling of the material for the whole process. South African workers found that gutting pilchards by machine under a 20-inch (50.8 cm.) vacuum was most effective for both firm and soft fish, whereas the use of a lower vacuum (9 to 12 inches or 22.9 to 30.5 cm.) resulted in a higher percentage of fish being imperfectly gutted (29). In French tuna canneries, stainless steel cutters, with a revolving berth, are used to cut the raw as well as the cooked tuna, handling 1,200 raw fish per hour, or cutting 20,000 slices of cooked fish per hour. In the Toquer system, the raw tuna fillets are cut and fitted into ring-shaped molds which carry them through a cooking and drying tunnel on a conveyer belt. The cooked meat is forced by a plunger from the cylindrical mold, and cut by a rotating knife into round slices which are transferred directly into the cans (31).

In Californian canneries (U.S.A.) the loins are pressed into rectangular blocks, which are cut into slices of can height. The slices are cut crosswise into cubes, which are pressed into cylinders and deposited directly into the cans (4). In another Californian cannery, tuna is packed without precooking. The canning line starts with four circular knives at right angles, which cut the fish lengthwise into four loins. Bones, tail, viscera and dark meat are removed by hand at a 10-station cleaning table. The fillets are skinned by machine and trimmed at another 10-station table before they are washed. The fillets are then pushed by plunger into the pockets of a centrifugal extractor which, revolving at high speed for 20 seconds, extracts most of the moisture. The extracted fillets are carried through a 10-blade revolving knife, and the cut off sections pushed on a conveyer belt to the can filler, a 6-pocket

horizontal turret filling 250 cans per minute. It takes 25 people to operate the line, which is claimed to give a 10% increased recovery per ton of tuna (13).

A new rotary sliming table has been introduced in Alaskan salmon canneries. It has a stationary outer ring with 9 working stations, and a slowly rotating, sloping center pan. It is said to be easy to clean and low in power requirements (2).

Increasing attention is also given to plant layout and its effects on material handling, processing costs and product quality (17).

BIBLIOGRAPHY

- (1) AALDERINK, J. F. M. Fish Canning. Salting of Pilchards for Canning. Purity of Salt. *Annual Report*, Fishing Industry Research Institute, Cape Town, Union of South Africa, (7) : 15.
- (2) ANON. Kodiak Fisheries Port Bailey Cannery. *Pacif. Fisherm.*, 1950 48 (9) : 26.
- (3) ———. Conclusive Consumer Acceptance Tests Precede Change in Product. *Food Processing*, Putnam Publishing Company Chicago 11, Ill., U.S.A., 12 (8) : 10.
- (4) ———. West Coast Corporation Unveils its Tuna Can-packing Invention. *Pacif. Fisherm.*, 49 (13) : 67.
- (5) ———. Brining Frozen Salmon Prior to Canning Reduces Texture Changes. *Fishery Products Report*, U.S. Fish and Wildlife Service, Washington 25, D.C., U.S.A., (130) : 1.
- (6) ———. Conserves d'esturgeon. *La Revue de la conserve*, 1952 Commerces et industries de l'alimentation, Paris 1 (72), January.
- (7) ———. Essais de préconservation des sprats en Norvège. *Ibid.*, 1952 (92), December.
- (8) ———. Frossenfisk og størjehmeretikk. *Tidskr. Hermetikind.*, 1952 38 (8) : 430.
- (9) ———. Canning Fish Chowder. *Food Engineering*, McGraw Hill Publishing Co., Inc., New York, 25 (11) : 186.
- (10) ———. New Canned, Prepared Salmon Product. *Pacif. Fisherm.*, 1953 51 (13) : 58.
- (11) ———. Anräuchern von Fischen im elektrostatischen Feld. 1954 *Allgemeine Fischwirtschaftszeitung*, Bremerhaven, W. Germany, 6 (5) : 4.
- (12) ———. Sulphide Discoloration in Canned Tuna. *Fishery Information Bulletin*, National Cannery Association, Washington 6, D.C., U.S.A., (27), 12 February.
- (13) ———. Economy Tuna Packing Process Unveiled. *Pacif. Fisherm.*, 1954 52 (3) : 63.
- (14) ———. Le fumage électrique des produits de la pêche. *Pêche marit.*, 33 (914) : 216.

- (15) ANON. Rock Lobster. Canning Tests. *Official Bulletin*, Fishing Industry Research Institute, Cape Town, Union of South Africa, (23).
- (16) ———. The Kitchen Concept in Seafood Canning. *Pacif. Fisherm.*, 35 (7) : 45.
- (17) ———. *Fishery Products Report*, Fishery Note No. 9, U. S. Fish and Wildlife Service, Washington 25, D. C., U.S.A.
- (18) ANZULOVIC, J. V. and REEDY, R. J. Pasteurization of Crab Meat. 1954 *Fish. Leafl., Wash.*, (415) : 1-7.
- (19) BALL, C. O. Food Sterilization Methods — The Future. *Food Technology*, Chicago 43, Ill., U.S.A., 9 (11) : 588.
- (20) BOURY, M. Préparation des conserves de civelles. *Pêche marit.*, 1951 *Bulletin d'information et de documentation*, (48), Series D : 1-3.
- (21) ——— and BONFILS, J. La mise en conserve de langoustes congelées. *Science et pêche*, Société des pétroles Shell Berre, Paris 8, 1 (10) : 8.
- (22) BUFFA, A. Sulla tecnologia delle conserve ittiche — Lavorazione industriale del tonno. *Industria Conserve*, Parma, Italy, 29 (1) : 26.
- (23) CALIFORNIA FISH CANNERS ASSOCIATION, Cal., U.S.A. (Personal communication).
- (24) CONTINENTAL CAN CO., Portland, Or., U.S.A. (Personal communication).
- (25) DREOSTI, G. M. and COOPER, C.E.B. Canned Fish. Economics of Chilling Pilchards. *Annual Report*, Fishing Industry Research Institute, Cape Town, Union of South Africa, (8) : 15.
- (26) DREOSTI, G. M. and VAN DER MERWE, R. P. Struvite in Canned Craw Fish. *Progress Report*, Fishing Industry Research Institute, Cape Town, Union of South Africa, (9).
- (27) ———. Rock Lobster, Pre-canning Treatment. *Annual Report*, Fishing Industry Research Institute, Cape Town, 1954 Union of South Africa, (7) : 16 ; (8) : 23.
- (28) DREOSTI, G. M. and ROWAN, A. N. Canned Fish. Process Control. *Ibid.*, (8) : 17.
- (29) EHMKE, C. W. Fish Canning. Mechanical Cleaning of Pilchards Prior to Canning. *Ibid.*, (7), 13.
- (30) ELLIOTT, H. H. and HARVEY, E. W. Biological Methods of Blood Removal and their Effectiveness in Reducing Discoloration. *Food Technology*, Chicago 43, Ill., U.S.A., 5 (4) : 163.
- (31) EMPEY, W. A. Fish Handling and Processing in Europe — Canning, Brising and Sild. *Fish. News Lett., Aust.*, 12 (4) : 15.
- (32) ———. Fish Handling and Processing in the U.S.A. — Crabs. 1954 *Ibid.*, 13 (5) : 15.
- (33) FISH INSPECTION LABORATORY, Halifax, Canada (Personal communication).
- (34) FISHING INDUSTRY RESEARCH INSTITUTE. Cape Town, Union of South Africa (Personal communication).

- (35) GRAVEN, H. J., and DASSOW, J. A. A Simple Penetrometefo.
1952 the Measurement of Texture Changes in Canned Salmorn
Technical Note No. 16, Comm. Fish. Rev., 14 (1) : 18.
- (36) HARDY, E. Fish for the Cannery. The Edible Crabs. *Canning*
1952 *Ind.*, 28 (327) : 30.
- (37) ———. Fish for the Cannery. The Edible Sharks. *Canning*
1953 *and Packing*, Canning Publications, London, E. C. 2.,
23 (275) : 7.
- (38) HARRIS, F. C. The Discoloration, Smut or Blackening of Canned
1923 Lobster. *Report*, Hon. Advisory Council for Scientific
and Industrial Research, Ottawa, Canada, (12) : 1-40.
- (39) HJOERTH HANSEN, S. Norwegian Studies on the Bacteriology of
1953 Semi-preserved Herrings. *SIK Publication*, Göteborg,
Sweden, (100), Chapter 3.
- (40) HOLLET, A. Magnesium-ammonium-phosphate Crystals Formation
1943 in Canned Lobsters. *J. Fish. Res. Bd. Can.*, 6 (2) : 183.
- (41) HOMANS, R. E. S. Canning Clams. *Circular*. Fish Inspection
1950 Laboratory, Halifax, Canada, (24) : 1-4.
- (42) JARVIS, N. D. Canning "Little Tuna" (*Euthynnus alleteratus*).
1952 *Food Technology*, Chicago 43, Ill., U.S.A., 6 (3) : 113.
- (43) JUL, M. Recent Progress in the Canning of Fisheries Products.
1951 *Fish. Bull. FAO*, FAO, Rome, Italy, 4 (5) : 3-27.
- (44) LANTZ, A. W., and GUNASEKERA, L. C. Investigation into the
1955 Keeping Qualities of Ungutted Fish from the Trawlers.
Progress Reports, Biological and Technological, Fisheries
Research Station, Colombo, Ceylon, (1) : 1.
- (45) LE ROUX, G. J., and VAN DER MERWE, R. P. Rock Lobster Can-
1952 ning. *Annual Report*, Fishing Industry Research Insti-
tute, Cape Town, Union of South Africa, (5) : 10.
- (46) MACCALLUM, W. A., et al. Keeping Time of Sardines (*Clupea pil-*
1956 *chardus* Walb) held under Refrigeration in the Frozen
or Unfrozen State Prior to Canning. *Food Technology*,
Chicago 43, Ill., U.S.A., 10 (9).
- (47) MAC PHAIL, A., and BRUÈRE, A. A. Discoloration in Canned Lob-
1897 sters. *29th Annual Report*, Canadian Department of Ma-
rine and Fisheries, Fisheries Branch, Ottawa, Canada,
Supplement (2) : 1-33.
- (48) MATHIESEN, E. Beretning fra Hermetikindustriens Laboratorium.
1954 1953. *Tidskr. Hermetikind.*, 40 (12) : 560.
- (49) ———. *Ibid.*, p. 561.
1954
- (50) ———. *Ibid.*, p. 564.
1954
- (51) McFEE, E. P. and SWAINE, H. L. Stops Struvite with New Tech-
1953 nique. *Food Engineering*, McGraw Hill Publishing Co.,
New York, 25 (12) : 67.
- (52) MEESEMACKER, R. and SOHIER, J. L. *Etudes et recherches sur la*
1956 *fabrication des conserves du Maroc*. Laboratoire de la
consERVE de poisson et de viande au service de la Fédéra-
tion des industries de la conserve au Maroc, Casablanca,
pp. 1-78.

- (53) VAN DER MERWE, R. P. Tuna Canning. *Memorandum*, Fishing Industry Research Institute, Cape Town, Union of South Africa, (35) : 1-2.
- (54) ————. Canned Snoek in Oil. *Annual Report*, Fishing Industry Research Institute, Cape Town, Union of South Africa, (4) : 8.
- (55) ————. Canned Abalone, Blue Discoloration. *Ibid.*, (8) : 23.
1955
- (56) ————. Rock Lobster. Citric Acid Treatment and Color and Flavor, *Ibid.*, 24.
1955
- (57) MIYAUCHI, D. T. and HEERDT, M., Jr. Salt Content of Salmon Canned from Brine-frozen Fish. *Comm. Fish. Rev.*, 16 (1) : 8.
1954
- (58) MURRAY, J. F. *et al.* The Sodium and Potassium Content of British Columbia Sea Foods. 1. Salmon and Tuna (in water) Canned without added Salt. *Progress Report of the Pacific Coast Stations*, Fisheries Research Board of Canada, Ottawa, Canada (101) : 17.
1954
- (59) NIELSEN, K. and RASMUSSEN, H. E. Vand i olie i Konservenprodukter. *Medd. Fisk Minist. Forsøgslab.*, October, pp. 1-5.
1952
- (60) PIGGOTT, G. and STANSBY, M. E. Iron Sulfide Discoloration of Tuna Cans. *Comm. Fish. Rev.*, 17 (10) : 34.
1955
- (61) POTTER, R. E. Carp and Cans — Today's Packing in Action. *Food Sci. Abstr.*, 21 (5) : 1210.
1949
- (62) REED, G. B. *et al.* A Bacteriological and Chemical Study of Some Problems in Lobster Canning. *Contributions to Canadian Biology*, New Series, Ottawa, Canada, 2 (1).
1924
- (63) ROWAN, A. N. Rock Lobster. Pre-Canning Treatment. Storage of Cooked Tails in Iced Water. *Annual Report*. Fishing Industry Research Institute, Cape Town, Union of South Africa, (7) : 16.
1954
- (64) ———— *et al.* Fish Canning. Salting of Pilchards for Canning. 1954 *Ibid.*, p. 13.
- (65) SCHNAKENBECK, W. Behandlung der Thunfische. *Fischwirtschaft*, 1955 1 (12) : 325.
- (66) SCHOONENS, J. G. Carbo-methyl-cellulose als hulpmiddel in de Visindustrie. *Visserijwereld*, The Hague, the Netherlands, 11 (18) : 13.
1952
- (67) STANDER, G. H. Canned Stockfish. *Annual Report*, Fishing Industry Research Institute, Cape Town, Union of South Africa, (4) : 8.
1951
- (68) STANSBY, M. E. Packaging Frozen Fish in Tin Results in Superior Storage Life. *Comm. Fish. Rev.*, 17 (7) : 17.
1955
- (69) ———— and DASSOW, J. Use of Frozen Salmon for Canning. 1951 *Ibid.*, 13 (4) : 20.

- (70) TANIKAWA, E. *et al.* Studies on the Manufacture of Canned Mackerel. Part 5. Studies on the Formation of Curd in Canned Mackerel. *Bulletin*, Faculty of Fisheries, Hokkaido University, Hokkaido, Japan, 3 (1) : 22.
- (71) ———. Studies on the Influence of Freshness of Raw Crab Meat and Duration of Storage after Boiling upon the Quality of Canned Crab Meat. *Ibid.*, 4 (1) 22.
- (72) TARR, H. L. A. Cause of the Browning of Certain Heat Processed Fish Products. *Progress Reports of the Pacific Coast Stations*, Fisheries Research Board of Canada, Nanaimo, B. C., (92) : 23.
- (73) ———. Canning. *Annual Report*, Pacific Fisheries Experimental Station, Fisheries Research Board of Canada, (9).
- (74) UNIVERSITY OF CALIFORNIA, Berkeley, Cal., U.S.A. Marine Technological Laboratory (Personal communication).
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Corrigenda

FAO Fisheries Bulletin Vol. IX, No. 3.

On p. 115, V. "Weather..." please read: "force 5-6 Beaufort wind scale maximum,..." instead of "minimum," as printed.

On p. 159, *Bulletin* No. 2. This periodical is published by the International North Pacific Fisheries Commission, University of British Columbia, Vancouver 8, B.C., Canada, instead of by the International Commission for the Northwest Atlantic Fisheries as stated.

THE INFLUENCE OF HYDROGRAPHIC CONDITIONS ON THE BEHAVIOR OF FISH*

(A preliminary literature survey)

Fishery workers throughout the world are active in their efforts to determine the identity and distribution of stocks of fish of economic importance and to measure the magnitude of these stocks, and moreover, to determine the seasonal and other changes which take place in these features. At present a preponderance of this research activity is directed towards a study of population as such. The following notes are intended to serve as a contribution to the thesis that, without seeking to diminish the importance of population studies, nevertheless many features of the population will ultimately be fully understood only when there has been effective analysis of the behavior of the individual organism. In this sense, the word "behavior" has been given a very broad connotation to signify not only the behavior of the individual fish in terms of taxes and tropisms but also the behavior of the physiological systems of which it is composed, notably the reproductive and digestive systems. These notes indicate that a much more careful view must be taken of the assumptions on which certain of the population work is based and in particular emphasize that certain responses of fish which might be dominant in certain circumstances may become of less importance in different circumstances, even if the primary stimuli which determine the original response continued in the new situation to be as strong as ever. This is especially true with respect to the temperature response.

Introduction

A commercial fishery will be profitable only if a high concentration of fish may be found in a restricted locality. In order to be able to predict the locality and time of aggregation of commercial fish the factors determining such aggregations must be identified and measured. Furthermore, the factors which determine successful propagation of the fish stock, its size, and survival rate must be found and identified too, in order to be able to take proper steps in management and fish conservation.

1. Organic Production

The producers of organic matter in sea water are the phytoplankton and the attached plants and seaweeds in shallow water. The factors controlling annual organic production in the sea are known, but the size of this annual production is not yet agreed upon. An attempt to estimate organic production in the open oceans is presented in the map opposite. This estimate is based

*Compiled by Richard H. Fleming, Department of Oceanography, University of Washington, and Taivo Laevastu, Biology Branch, FAO, Rome Italy.

on consideration of the following factors :

1. measurements of organic production by the Carbon-14 method (Steemann-Nielsen 1954);
2. measurements by oxygen production methods;
3. calculations from oxygen and nutrient depletion;
4. the existing size of standing crops of plankton (Friedrich 1950; Nakai 1941);
5. the availability of nutrients;
6. other factors, such as seasonal changes of temperature, light energy, turbulent mixing, etc.

The estimate represented by the diagram is not fully satisfactory for the use of fisheries hydrography because it does not take into account the large and variable organic production in coastal water, and it gives insufficient detailed information concerning the concentration of plankton in restricted areas, important for fisheries.

Most of the commercially important fish enter shallow coastal areas in certain periods of their lives. This behavior is directly or indirectly related to the higher production of organic matter in coastal areas, which may be attributed to the following:

- (1) higher amounts of plant nutrients are available, provided, usually, by turnover and mixing of nutrient-rich subsurface water by tidal currents, and by cascading of water masses;
- (2) there is a surplus of nutrients and organic detritus from land and river waters, and
- (3) there exists here one more biological division of aquatic life — the benthos, which consists of attached plants in shallow water and the infauna and epifauna of the bottom. The total standing crop of benthos is often several orders of magnitude higher than that of the plankton.

The following phenomena affect the organic production of plankton organisms in offshore water :

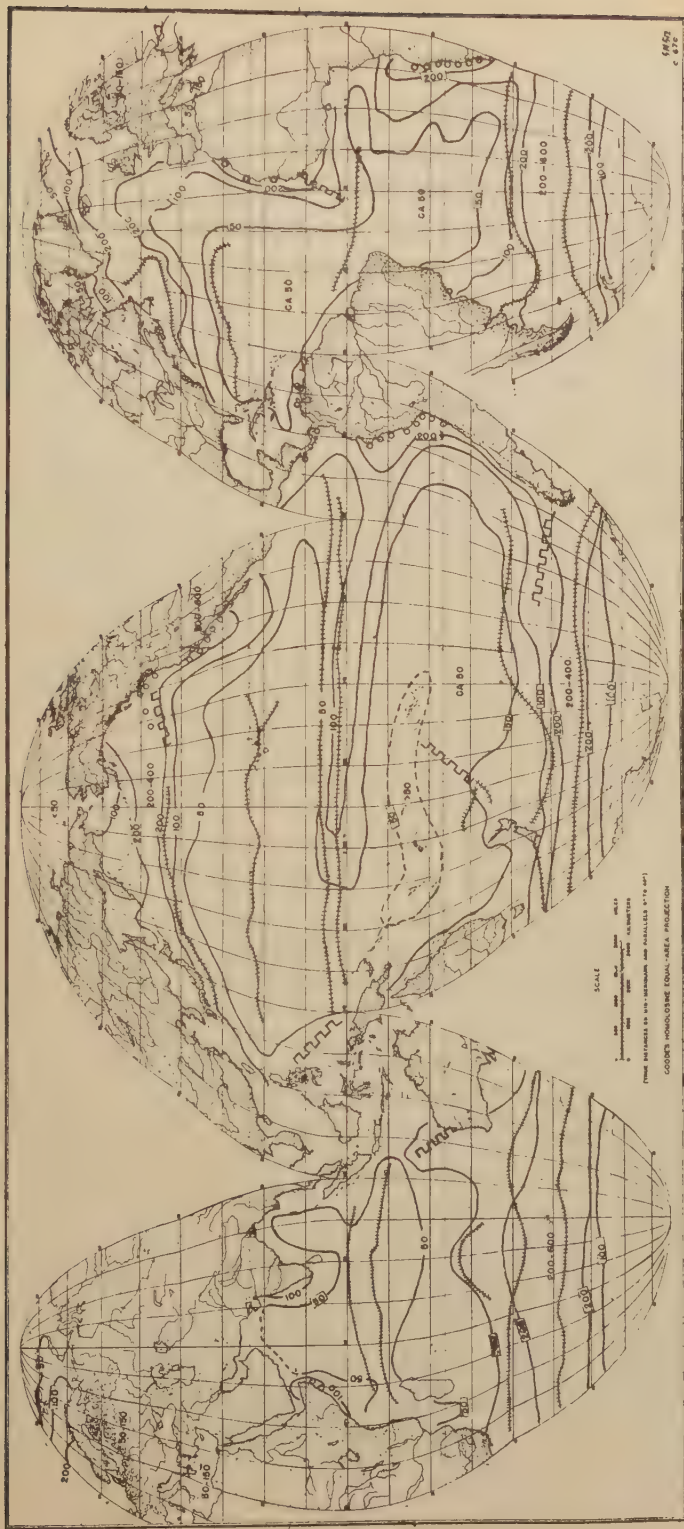
- (a) divergences with upwelling and convergences of the currents, and
- (b) water mixing caused by tidal and wind currents moving around islands and offshore submarine features.

These are subject to seasonal change and irregular fluctuation. Knowledge of them and their fluctuation has been used with success by Japanese fishermen in tracing the aggregations of pelagic fish (Shapiro 1950).

The size of the standing crop of the benthos is influenced by the following :

- (i) depth with which there is an inverse relation (Brotskaja and Zenkevich 1939);
- (ii) the texture of the sediment and the amount of organic substance present in the sediment;
- (iii) the ventilation of the sediment surface and the movements of water above it which increases the standing crops.

ESTIMATION OF THE PRODUCTION OF ORGANIC MATTER IN THE OCEANS (gC/m² per year)



ESTIMATIONS OF STANDING CROPS IN THE SEA

Locality	Amount	Basis of Evaluation	Author or Source	
<i>Phytoplankton</i>				
English Channel June	150 mg./m ²	dry org. matter	Atkins, Jenkins	
April	1,320 mg./m ²		1953	
Antarctic Ocean	3.4 to 38 mg./m ³		Hart 1942	
Georges Bank-average	192 mg./m ³		Riley, Bumpus 1946	
Off Plymouth	4,000 mg./m ³		Harvey 1950	
<i>Zooplankton</i>				
Off Plymouth	1.6 to 3.5 g./m ² mean 1.5 g./m ²	dry org. matter	Harvey 1950	
Gulf of Main	9 to 20 g./m ²		Riley 1941	
Barents Sea-summer	13.8 mg./m ³		{ Jaschnov 1939	
winter	3 "			
average	8.4 "			
Long Island Sound	3.2 g./m ²		Riley 1941	
Open Ocean	1.8 "		" "	
<i>Bacteria</i>				
Sea water	40 mg./m ²	dry org. matter	Harvey 1950	
Bottom	100 "		" "	
<i>Benthos</i>				
Barents Sea 0 to 100 m.	300 g./m ²	biomass	Filatova 1938	
300 to 400 m.	48 "		" "	
Edges of banks and contin. slope	100 to 500 g./m ²		" "	
Greatest part	50 g./m ²		" "	
Deeper parts against Atlantic	10 "		" "	
North Sea	500 "		Petersen, Jensen 1911	
Open Kattegat	35 "		" " "	
Baltic Sea	15 "		" " "	
Off Plymouth	100 "		Harvey 1950	
Bay of Anadyr	228 "		Derjugin, Iwanov 1937	
North Bering Sea	777 "		" " "	
San Juan Archipelago	1,380 "		Fleming, Laevastu M. S.	
<i>Fish</i>				
Off Plymouth				
Pelagic fish	1.8 g./m ²	dry org. matter	Harvey 1950	
Demersal fish	1 to 1.25 g./m ²		" "	
Bering Sea				
Salmon	3 g./m ²	biomass	Estimate from experimental offshore fishery	
<i>Yield of Fish</i>				
U. S. continental shelf	1.8 g./m ²	biomass	Taylor 1951	
Alaska, average comm. catch	20.0 "		{ on fishing grounds	{ Different sources
Puget Sound average comm catch	12.0 "			
North Sea - Herring	2.5 "			
Other fish	0.9 "			

(Plankton 1 g. biomass = 0.06 g. Dry organic matter)

Thorson (1955) has found that the same types of level bottom substrata at similar depths are quantitatively dominated all over the world by invertebrates belonging to the same genera but to different species. Furthermore, the size of the standing crop of these characteristic communities varies within relatively narrow limits (Spärek 1935). Therefore, knowing either the benthos community on a particular locality or the type of bottom substrata and depth, one can roughly estimate the amount of available fish food on the bottom.

Relatively few estimates have been made of the bacteria population in the sea. The investigations of Krey (1953) indicate that the population may be higher than had been previously thought. The bacteria in sea water and on the bottom is considered as a partial food source for some plankton organisms and even for some commercial species such as the oyster. Recent investigations by Fleming and Laevastu (M.S.) show that in certain areas and seasons high standing crops of bacteria can depress the production of organic matter by direct attack on phytoplankton.

Some of the estimates of standing crops of different marine biological divisions are represented on the table on page 183. These calculations are only approximate because of great seasonal variations and the patchiness of the standing crop of plankton, as well as differences in vertical distribution. It is known that the ratio of zooplankton to phytoplankton can vary in higher latitudes from 1 : 25 in early summer to 1 : 1 in winter. Furthermore, the maximum zooplankton concentration is found during the summer in the upper 75 meters and during the winter, in 150 to 600 meters.

II. Food Chains in the Ocean

The different biological groups represent a continuous chain in relation to food potential. The first link is composed of the phytoplankton, plants and seaweeds, the second link of zooplankton and some omnivorous animals, and the third link of the plankton-eating fish. MacGinitie (1949) estimates the food coefficient at 1 : 10 in every link. This coefficient decreases with increasing abundance of food and increases with decreasing food supply.

Using the following values : basic organic production 150 g. carbon/m²/year, commercial catch of herring 2.5 g./m²/year and other fish 0.9 g./m²/year, calculations show that 20% of the annual phytoplankton production passes directly or indirectly through the digestion of commercially caught fish in the North Sea.

The commercial catch of fish is profitable if the concentration is within a limited, vertical distribution and at least 10 to 50 g. fish per m², depending on the value of the fish and the method and equipment of fishing. For comparison, the standing crop of salmon in the Bering Sea is estimated to be about 3 g./m², and, according to Harvey (1950), the concentration of pilchard can be as high as 1 kg./m². Considering the calculation for the North

Sea, it becomes obvious that because of the insufficiency of fish food the concentrations necessary for commercial operations cannot be permanent. These fish may congregate for a short time in a certain place for spawning, to graze on an unusually high concentration of food, or for other reasons, but must soon disperse.

In order to analyze the reasons for the aggregation of fish and to predict the time and place of such concentrations, some of the controlling factors, using different sources of data, are discussed on the following pages.

Furthermore, the data on standing crops of fish food can be used for estimation of maximum possible populations.

III. Temperature

Temperature is the most easily determined environmental factor, therefore, numerous workers have attempted to correlate the behavior of fish with temperature and they regard it as the most important environmental factor. However, changes of temperature in oceanic environment are very often only concomitant changes of other factors, such as currents and other water movements, whose influence may be considerable and in these cases the influence of temperature may be of relatively little significance.

According to Sullivan (1954) temperature change may act on fish as :

- (1) a nervous stimulus,
- (2) a modifier of metabolic processes, and
- (3) a modifier of bodily activity.

From carefully designed experiments Bull (1952) concluded that "Individual teleosts perceive and react purposively to minimal changes in water surrounding them : 0.03° C. temperature, $0.2^{\circ}/_{\infty}$ salinity and 0.05 pH."

The lowest temperature at which a fish may survive depends upon its previous acclimatization. The freezing point of fish body fluids is between 31.1° to 30.4° F. (-0.5° and -0.9° C.) Doudoroff's (1942) experiments show that fish normally living in water 53.6° to 77° F. (12° to 25° C.) are killed by temperatures well above 32° F. (0° C.). Galloway (1941) has recorded extensive mortality of fish in the coastal areas of Florida, U.S.A., when the minimum temperature was as high as 57.2° F. (14° C.). In the North Sea, Simpson (1953) has found that cod can tolerate 37.4° F. (3° C.) and plaice 33.8° F. (1° C.) and that temperatures slightly under 32° F. do not injure the fish. According to Simpson (1953) W. C. Smith has found that 43% of plaice survived in the hatchery when the water temperature was below 32° F. and the mean weekly minimum was 30.6° F. (-0.8° C.).

Lee (1952) states that the lowest optimum temperature limit for cod in the Barents Sea is 35.2° F. (1.75° C.), if the temperature of bottom water is below this, commercial fishing is unprofit-

able. However, occasionally cod can be found in water with a temperature as low as 30.9° F. (-0.6° C.). In this case the fish are usually grazing on krill, which are concentrated in the areas with low temperatures. Lee concluded from this observation that fish can aggregate along the boundaries of the areas with unfavorable environmental factors if the food is present in high quantities in the areas with unfavorable conditions for fish. However, he remarks that the relations between the nonspawning cod and temperature are not great, but good correlation can be found during the spawning period.

Tåning (1953) summarizes the influence of long-term temperature increase in the Northern Hemisphere on the distribution of fish as follows :

- (a) spawning on the southward limit is diminished and on the northward limit increased ;
- (b) increase in bottom water temperature can produce changes in spawning grounds ;
- (c) nursery and feeding grounds have been opened to the north ;
- (d) the increase in the amount of food by rise in temperature in higher latitudes and the changes in currents and in amount of nutrient salts present ;
- (e) growth period is prolonged, and
- (f) the limit at which larvae can survive is shifted further to the north.

Certain fish stocks have specific optimum temperatures. Sullivan and Fisher (1953) have found that in autumn and the beginning of winter the fish select progressively lower temperatures, the change being slow in autumn but quite rapid at the beginning of winter. Then in spring, independently of changes in water temperature, the fish seek higher temperatures. Sullivan (1954) states that fish select a certain temperature because of its effect on the movement (activity). Thompson (1943) has found that catches of cod, in relation to temperature, vary with the season near Newfoundland. The best catches are obtained by a temperature of 32° to 37.4° F. in spring and 38.3° to 41.9° F. (3.5° to 5.5° C.) in summer. Further information on the behavior of cod in relation to temperature is given by Hachey, Hermann and Bailey (1954).

The influence of temperature becomes much more pronounced during the spawning season. Different fish stocks of the same species narrow temperature limits for spawning (Pertseva 1939). The cod spawn in Motovsky Bay three weeks later than by the Lofoten Island and 1½ to 2 months later than in the North Sea. Other temperature limits for cod spawning are : Motovsky Bay 32.7° to 35.6° F. (0.4° to 2° C.), northern Norwegian waters 36.5° to 41° F. (2.5° to 5° C.), Skagerrack 39.2° to 43° F. (4° to 6° C.), and Newfoundland waters 37.4° to 41° F. Abnormal temperatures during the spawning season can delay spawning or force the fish to spawn in other areas than their normal spawning grounds (Simpson 1953).

According to Rounsefell (1930), the survival of Pacific herring is related to the water temperature during and after spawning.

The temperature of the water also influences the intensity of feeding. Komarova (1939) has found that feeding intensity decreases with increasing temperature. Little or no feeding takes place in the Barents Sea during March or April.

Galtsoff (1924) and Pektaş (1954) have related the seasonal migrations of Mackerel in the Black Sea to the temperature.

IV. Salinity

The salinity of the water has direct influence on the survival of fish with buoyant eggs. Furthermore, the salinity determines the plankton spectrum and hence the availability of suitable food, especially for fish larvae. The influence of salinity on the distribution and behavior of fish is most pronounced in estuaries and in seas with brackish water, such as the Baltic Sea. The direct influence of salinity on behavior and growth rate depends upon the degree of salinity of each species.

V. Other Physical and Chemical Environmental Factors

Air bubble disease, caused by supersaturation of water with dissolved gases, may be a common danger for fish, as the investigations of Henly (1952) and Dannevig (1950) show. The low content of dissolved oxygen may be a factor influencing the distribution of fish inhabiting restricted areas such as some deep Norwegian fjords and deep holes in the Baltic.

Allen (1909) has found that the amount of light in early Spring affects the survival of fish larvae. It is probable that in this case the influence is through the amount of organic production, which is directly dependent on the availability of light energy. Sullivan and Fisher (1953) state that the amount of light available can influence the maturity time of the fish. According to Bull (1952), Blinnius has found fish to possess a well developed color vision, but Bull failed to condition all fish visually. Balls (1951) has found that adult herring avoid high light intensities and have diurnal vertical phototaxic migrations.

VI. Currents

Bull (1952) has found no response in fish to the rate or direction of the current flow. On the other hand, the currents have great importance in the distribution of fish food. Feeding fish usually drift with the water mass (Bullen 1912). Carruthers, Lawford and Veley (1951) have offered an account of brood survival based on the fact that currents may carry fish larvae into regions where food and other environmental factors are unfavorable. Walford (1938) points out the same effect on the survival of haddock.

VII. Food and Feeding Habits

The average food spectrum of commercial fish in the Barents Sea consists of approximately 50% benthos, 35% other fish and 15% plankton. The proportion of benthic organisms in the food is higher for young fish than old, the latter eat a higher proportion of nektonic organisms. Komarova (1939) and Jespersen (1928) have found that the food spectrum of fish varies with seasons and locality. Fish usually prefer large zooplankton organisms. According to Zadulskaja and Smirnov (1939) the most intensive feeding takes place during the day: in winter, 16.00 to 20.00, in spring, 12.00 to 16.00 and in summer and autumn 08.00 to 12.00 o'clock. The feeding is also most intensive during the middle neap and middle spring tides.

Brotsky (1931) has found that cod form dense schools in the Barents Sea when food is scarce and disperse on entering a region where food is abundant. Russell (1952) points out that fish food is usually widely distributed during the summer but in the autumn it is scarce thus affecting the fish distribution during the winter and spring. Further, he points out that the chemical and physical factors of environment have little direct influence on fish while they are grazing. Jensen (1950) and Jespersen (1928, 1932, 1936, 1944) have found correlation between the amount of the suitable herring food in plankton and the catches of herring. Nakai and Honjo (1954) point out that the catch of salmon in the North Pacific is maximal in areas with large zooplankton standing crops.

The correlation between basic organic production, the amount of herring present, and the survival rate of larvae has been pointed out by Russell (1952) and others. The correlation between the size of standing crops of zooplankton and the possibilities for good commercial catch of herring has been applied in practice by fishermen in the North Sea.

Pchelkina (1939) investigated the behavior of herring in the Barents Sea. Her principal results were as follows:

- (1) in March, herrings rise to the upper layers of water and migrate to shallow areas;
- (2) in April, they begin schooling;
- (3) in May, they are found in the areas with rose-colored *Calanus*;
- (4) in June and July, there is a correlation between the zooplankton biomass and herring biomass;
- (5) from August to October they have reduced the plankton by grazing, and negative correlation between zooplankton and herring is found.

For several species it is assumed that the abundance of food for the larval stage of fish is the factor determining the size of the stocks. According to Wiborg (1948) there are 10 to 20 cod larvae and 5,000 to 25,000 food organisms in each cubic meter of water.

Several organisms can drive fish away from an area. The red tide caused by *Gymnodinium* species is one such example. Furthermore, herrings are usually not found in quantities where there are large standing crops of *Phaeocystis* and *Rhizosolenia*. According to Lee (1952), cod are not taken from waters where certain sponges and *Aleyonidium* is found in quantity.

VIII. Summary and Discussion

The relations between fish and the physical and biological components of their environment are complex. To date, the amount of information is relatively small. For convenience of review, the problem may be outlined under the following headings:

Effect of environment on:

- A. Development of eggs and larvae
- B. Movement and behavior of immature and adult fish
- C. Rate of growth
- D. Migrations
- E. Spawning

A. Development of Eggs and Larvae

The development of the egg and larvae is undoubtedly the most critical period in the life history of the fish because this is when they are most strongly influenced, directly and indirectly, by physical conditions. Temperature directly influences the rate of development and, when combined with salinity, will determine the prevailing water density, and thus affect the buoyancy of the eggs. It may be assumed that unusually high or low temperatures are avoided by spawning stocks. Currents, permanent or local wind-generated currents, transport pelagic eggs and larvae. The availability of proper food for the larvae at the proper time is another very important element, and is related to the basic phytoplankton production. There is no logical reason for supposing that the spawning of fish and the development of suitable food for the larvae should be interdependent at any given locality in a given year.

B. Movement and Behavior of Immature and Adult Fish

If, as generally assumed, fish search for and select some optimum combination of physical and biological conditions, it follows that seasonal and year-to-year variation in conditions will result in varying abundance and distribution. The problem is complicated by the fact that undoubtedly requirements change during the various stages of growth. Furthermore, some investigations indicate that the temperature requirements of certain species change seasonally.

C. *Rate of Growth*

Rates of growth depend largely upon the availability of appropriate food. Rates of feeding and of digestive metabolism are, however, affected by physical factors such as temperature of the water and by the presence of distasteful organisms. Temperatures falling below optimum usually reduce feeding activity. It has also been found that abnormally high temperatures cause a decrease in feeding and that fish form dense schools when food is scarce, and disperse when food is abundant. The food distribution and abundance is most critical during winter and spring. When food is abundant, the physical conditions are of relatively little importance. Although the data available are only scanty it is generally assumed that at each step in a food chain about 10% of the food is converted to body weight.

D. *Migrations*

Migrations are characteristic of many marine fishes. Local movements, particularly if seasonal, are usually related to changing physical conditions or to varying food supplies. It is, however, much more difficult to explain the major movements of such forms as salmon, tuna, eels, etc. To do this some or all of the following possibilities would have to be considered:

- (1) Passive drift with currents.
- (2) Search for adequate food.
- (3) Changing physiological requirements during life history.
- (4) Relict behaviors established during past geological ages.
- (5) Purposeful movements made without regard to the environment.

Hart (1946) has summarized many of the recognized features on the fish distribution on the Patagonian shelf as follows:

- (a) Many demersal fishes show seasonal movement shoreward in summer and offshore to deeper water in winter. Usually, but not always, the shoreward movement is a breeding migration.
- (b) In a migratory species of ground fish, the larger fish tend to travel farther and faster than the smaller ones. (Often the movement of immature fish is so limited that they never proceed "over the edge" to the greater depths reached by the adults during the "off" season).
- (c) In temperate latitudes, many migrating species of demersal fishes extend their range poleward in summer and toward the equator in winter. This may result directly from the effect of temperature, but is not (as yet) clearly to be distinguished from secondary effects of the strength and direction of the currents (the factor most strongly emphasized by Meek). Thus, it is essential for fish with denatant pelagic larvae, inhabiting a region such as the Patagonian continental

shelf (where the main current flows from south to north), to spawn near the southern limit of their range (or so close inshore that the larvae are drifted by the inshore counter current to the southward), if the species are to be maintained within their ecological norm. A considerable meridional trend of seasonal movement may thus be superimposed upon the on and offshore movement, and may even almost mask the latter.

- (d) Among demersal species which have an extensive depth range, the larger fish usually reach deeper water, although this tendency may temporarily be masked by seasonal movements. A similar tendency can sometimes be discerned interspecifically, but there are many obvious exceptions (such as large, exclusively littoral species) if purely taxonomic units are considered.
- (e) Fish of wide latitudinal range often show a gradation of size with latitude, with the larger fish towards the polar limits of the range of the species. This implies either that the stocks are different in different latitudes (with different spawning times), as has been shown for European hake, or that only the larger fish penetrate towards the polar limits of the range of the species or that those fish which do penetrate to the polar regions grow larger.
- (f) In many fish a marked change in diet occurs with increasing size (age). This may often coincide with the attainment of sexual maturity and/or greatly increased migrations.

E. *Spawning*

Spawning is a seasonal activity related to the physiological development or cycles of the adult fishes. Certain interdependent requirements, such as appropriate temperatures, types of bottom, salinities, etc., may have to be met. Subnormal temperatures are known to cause shifts in the spawning areas and/or to delay spawning. These can result in unfavorable conditions for the eggs and larvae.

Acknowledgments

The authors wish to express their thanks to Dr. A. C. DeLacy of the School of Fisheries, University of Washington, and Dr. G. L. Kesteven, Chief, Fisheries Biology Branch, for valuable criticism and editing of this paper.

BIBLIOGRAPHY

- ALLEN, E. J. Mackerel and Sunshine. *J. Mar. biol. Ass. U. K.*, 8 : 1909 394-406.
- ATKINS, W. R. G. and JENKINS P. G. Seasonal Changes in the Phytoplankton during the Year 1951/52 as Indicated by Spectrophotometric Chlorophyll Estimations. *Ibid.*, 31 (3) : 495-508.
- BALLS, R. Environmental Changes in Herring Behaviour: A Theory of Light Avoidance as Suggested by Echo Sounding Observations in the North Sea. *J. Cons. Int. Explor. Mer.* ~~16~~¹⁷ (3) : 274-98.
- BROTSKAJA, V. A. and ZENKEVICH, L. A. Quantitative Study of the 1939 Bottom Fauna of the Barents Sea. *Trans Inst. Mar. Fish. U.S.S.R.* 4 : 5-126.
- BROTSKY, V. A. Report on the Feeding of Cod. *Report First Session 1931 State Oceanographic Institute. Moscow*, 4 : 56-58.
- BULL, H. O. An Evaluation of our Knowledge of Fish Behaviour in 1952 Relation to Hydrography. *Rapp. Cons. Explor. Mer.*, 131 : 8-23.
- BULLEN, G. E. Some Notes on the Feeding Habits of Mackerel and 1952 Certain Clupeoids in the English Channel. *J. Mar. biol. Ass. U. K.*, 9 : 394-403.
- CARRUTHERS, J. N., LAWFORD A. L., and VELEY V. F. C. Fishery 1952 Hydrography: Brood Strength Fluctuations in Various North Sea Fish with Suggested Methods of Prediction. *Kieler Meeresforsch.*, 8 : (1) : 5-15.
- DANNEVIG, ALF and GUNNAR. Factors Affecting the Survival of Fish 1950 Larvae. *J. Cons. Int. Explor. Mer.*, 16 (2) : 211-15.
- DERJUGIN, K. M. and IWANOV, A. W. Vorläufige Übersicht der benthonischen Arbeiten der Pazifischen Expedition vom Jahre 1932-33 in den Bering und Tschuktschen Meeren. *Explor. Mers. Russes*, 25 : 246-59.
- DOUDOROFF, H. P. The Resistance and Acclimatization of Marine 1942 Fishes to Temperature Changes, I. Experiments with *Girella nigricans* (Ayres). *Biol. Bull., Woods Hole*, (2) : 219-44.
- FILATOVA, Z. A. The Quantitative Evaluation of the Bottom Fauna 1938 of the South-western Part of the Barents Sea. *Trans. Knipovich polar Sci. Inst.*, 2 : 3-58.
- FLEMING, R. H., and LAEVASTU, T. Quantitative Evaluation of Bot- (MS.) tom Fauna in the San Juan Archipelago.
- . Relations of Marine Bacteria to the Organic Production and (MS.) the Seasonal Cycle of Plankton Population in the Sea.
- FRIEDRICH, H. Versuch einer Darstellung der relativen Besiedlungsdichte 1950 in den Oberflächenschichten des Atlantischen Ozeans. *Kieler Meeresforsch.*, 7 (2) : 108-21.
- GALLOWAY, J. C. Lethal Effect of the Cold Winter of 1939/40 on Ma- 1941 rine Fishes at Key West, Florida. *Copeia*, (2) : 118-19.
- GALTISOFF, P. S. Seasonal Migrations of Mackerel in the Black Sea. 1924 *Ecology*, 5 (1) : 1-5.

- HACHEY, H. B., HERMANN, F. and BAILEY, W. B. The Waters of the 1954 ICNAF Convention Area. *Annual Proceedings*, International Commission for the Northwest Atlantic Fisheries, Halifax, Canada, 4: 67-102.
- HART, T. J. Phytoplankton Periodicity in Antarctic Surface Waters. 1942 "*Discovery*" *Rep.*, 21: 261-356.
- . Report on Trawling Survey on the Patagonia Continental Shelf. *Ibid.*, 23: 225-408.
- HARVEY, H. W. On the Production of Living Matter in the Sea off 1950 Plymouth. *J. Mar. biol. Ass. U. K.*, 29: 97-137.
- HENLY, E. The Influence of the Gas Content of Sea Water on Fish and 1952 Fish Larvae. *Rapp. Cons. Explor. Mer.*, 131: 24-27.
- JASCHNOVA, W. Plankton Productivity of the South-western Part of 1939 the Barents Sea. *Trans. Inst. Mar. Fish. U.S.S.R.*, 4: 201-24.
- JENSEN, A. I. C. Changes in the Quality of the Herring in the Course 1950 of the Year and from Year to Year. *Rep. Danish biol. Sta.*, 41: 1-17.
- JESPERSEN, L. Investigation on the Food of the Herring in Danish 1928 Waters 1928. *Medd. Komm. Havundersøg. Kbh., Plankton*, 2 (2): 150.
- . Investigation on the Food of the Herring in Islandic Waters 1932 *Ibid.*, 2 (3): 34.
- . The Food of the Herring in the Waters Round Bornholm. 1936 *Ibid.*, 3 (2): 40.
- . Investigation on the Food of the Herring and the Macro- 1944 plankton Round the Faroes. *Ibid.*, 3 (7) 1-43.
- KOMAROVA, T. V. Feeding of the Long Rough Dab in the Barents Sea 1939 in Connection with Food Resources. *Trans. Inst. Mar. Fish. U.S.S.R.*, 4: 298-320.
- KREY, J. Plankton und Sestonuntersuchungen in der südwestlichen 1953 Nordsee auf der Fahrt des "Gauss" Februar/März 1952. *Ber. dtsh. Komm. Meeresforsch.*, 13 (2): 136-53.
- LEE, A. T. The Influence of Hydrography on the Bear Island Cod 1952 Fishery. *Rapp. Cons. Explor. Mer.*, 131: 74-102.
- MACGINITIE, G. E. and N. *Natural History of Marine Animals*. McGraw 1949 Hill, New York, 473 pp.
- NAKAI, Z. Plankton in Pacific Ocean (In Japanese). *Kaiyo no Kagaku*, 1941 2: 45-52.
- and HONJO, K. A Preliminary Report on Surveys of Plankton 1954 and Salmon Stomach Contents from the N. Pacific 1952. Fisheries Agency, Tokai Fisheries Research Laboratory. *Publication*, 3: 6-12.
- PHELKINA, N. V. The Relations Between the Herring and Zooplankton 1939 in the Barents Sea. *Trans. Knipovich polar Sci. Inst.*, 4: 109-28.
- PEKTAS N. Uskumrularin muhtemel muhaceret sebepleri ve bu konuda 1954 muhit subunetinin rolü. [The Probable Cause of Migration of Black Sea Mackerel and the Part Played by Temperature]. (In Turkish). *Hidrobiolgi Mecmuasi, İstanbul. Ser A* 2 (3): 113-21.
- PERTSEVA, T. A. Spawning, Eggs and Fry of Fish in Motovsky Bay. 1939 *Trans. Inst. Mar. Fish U.S.S.R.*, 4: 412-70.

- PETERSEN, C. G. J. and JENSEN, P. B. Valuation of the Sea. I.
1911 Animal Life of the Sea Bottom, its Food and Quantity. *Rep. Danish biol. St.*, 20 : 3-79.
- RICHARDSON, J. D. Some Reactions of Pelagic Fish to Light as Recorded
1952 by Echo Sounding. *Fish. Invest. London.*, Ser. 2, 18 (1).
- RILEY, G. A. Plankton Studies. V. Regional Summary. *J. Mar. Res.*, 4 (2) : 162-71.
- and BUMPUS, D. F. Phytoplankton-Zooplankton Relationship
1946 on Georges Bank. *Ibid.*, 6 (1) : 33-47.
- ROUNSEFELL, G. A. The Existence and Causes of Dominant Year
1930 Classes in the Alaska Herring. *Contributions to Marine Biology, Stamford University*, pp. 260-70.
- RUSSELL, F. S. The Relation of Plankton Research to Fisheries Hydro-
1952 graphy. *Rapp. Cons. Explor. Mer.*, 131 : 23-34.
- SHAPIRO, S. The Japanese Long Line Fishery for Tunas. *Comm. Fish*
1950 *Rev.*, 12 (4) : 1-26.
- SIMPSON, A. C. Some Observations on the Mortality of Fish and the
1953 Distribution of Plankton in the Southern North Sea during the Cold Winter 1946-47. *J. Cons. Int. Explor. Mer.*, 19 (2) : 150-77.
- SPARCK, R. On the Importance of Quantitative Investigation on the
1935 Bottom Fauna in Marine Biology. *Ibid.*, 10 (1) : 3-19.
- STEEMANN-NIELSEN, E. On Organic Production in the Oceans. *Ibid.*,
1954 19 (3) : 309-28.
- SULLIVAN, C. M. Temperature Reception and Responses in Fish. *J. Fish.*
1954 *Res. Bd. Canada*, 11 (2) : 153-70.
- and FISHER, R. C. Seasonal Fluctuations in the Selected
1953 Temperature of Speckled Trout (*Salvelinus fontinalis*). *Ibid.*, 10 (4) : 187-95.
- TAYLOR, F. H. *Economics of Fisheries of North Carolina, Survey of*
1951 *Marine Fisheries of North Carolina*. University of North Carolina Press, Chapel Hill, Car., U.S.A., pp. 289-540.
- TÄNING, V. Å. Annual Proceedings, International Commission for the
1953 Northwest Atlantic Fisheries Halifax, Canada. (Articles on long-term temperature changes and fisheries). *Ann. Proc.* 3. 1952/53.
- THOMPSON, H. A Biological and Economic Study of Cod (*Gadus callarias*
1943 L.) in the Newfoundland Area. *Res. Bull. Div. Fish. Resour. Newfoundland.*, (14).
- THORSON, G. Modern Aspects of Marine Level-bottom Animal Commu-
1955 nities. *J. Mar. Res.*, 14 (4) : 387-97.
- WALFORD, L. A. Effect of Current on Distribution and Survival of
1938 the Egg and Larvae of the Haddock (*Melanogrammus aeglefinus*) on Georges Bank. *Bull. U.S. Bur. Fish.*, 4a (29).
- . Correlation between Fluctuations in Abundance of the Pa-
1946 cific Sardine (*Sardinops caerulea*) and Salinity of the Sea Water. *J. Mar. Res.*, 6 (1) : 48-53.
- WIBORG, K. F. Investigations on Cod Larvae in the Coastal Waters
1948 of Northern Norway. Occurrence of Cod Larvae and Occurrence of Food Organisms in the Stomach Contents and in the Sea. *Rep. Norway Fish. Invest.*, 9 (3) : 1-27.
- ZADULSKAJA, E. S. and SMIRNOV, K. A. Diurnal Process of Feeding in
1939 Cod in the Fishery Grounds of the Barents Sea. *Trans Inst. Mar. Fish. U.S.S.R.*, 4 : 321-38.

General References in Fisheries Hydrography

- ANON. Research and Fishing : The Plankton and the Herring. *World Fishing*. John Trundell Ltd., London E.C.4. October. pp. 404-10.
- BUCH, K. The Cycle of Nutrient Salts and Marine Production. *Rapp. Cons. Explor. Mer.*, 132 : 36-46.
- CARRUTHERS, J. N. An Attitude on "Fishery Hydrography". *J. Mar. Res.*, 10 (1) : 101-18.
- FRIEDRICH, H. Die Planktonkunde des Meeres, ein Ergebnis integrierende Forschung. *Veröff. Inst. Meeresforschung Bremerhaven*, 3 (1) : 1-8.
- HAGMEIER, A. Die Nahrung der Meerestiere. Die Bodenfauna. *Handb. Seefisch. Nordeurop.*, I. (5 b).
- KALLE, K. Der Mechanismus des ozeanischen und kontinentalen Produktionsvorganges. *Dtsch. hydrogr. Z.* 23 (1/2) : 62-68.
- KESTEVEN, G. L. A Procedure of Investigation in Fisheries Biology. 1946 Commonwealth of Australia. *Bull. Comm. Sci. Industr. Res., Austr.*, (154).
- KREY, J. Über die Fruchtbarkeit des Meeres. *Veröff. Inst. Meeresforschung Bremerhaven*, 2 (1) : 1-14.
- KÜNNE, C. Die Nahrung der Meerestiere, Das Plankton. *Handb. Seefisch. Nordeurop.*, (5 a).
- RILEY, G. A. Survey of Biological Progress. *Academic Press, N.Y.*, 2 : 79-103.
- STEEMANN-NIELSEN, E. Havets planteverden i økologisk og produktionsbiologisk belysning. *Skr. Komm. Havunders., Kbh.*, (13).
- SVERDRUP, H. U. Some Aspect of the Primary Productivity of the Sea. 1952 *Fish. Bull. FAO*, 5 (6) : 215-23.
- . Some Remarks on the Place of Hydrography in Fisheries Research. *Rapp. Cons. Explor. Mer.*, 131 : 7.
- TAIT, T. B. *Hydrography in Relation to Fisheries*. Edward Arnold 1952 & Co., London. 106 pp.
- WIMPENNY, R. S. Plankton. *Rapp. Cons. Explor. Mer.*, 132 : 28-35.
- ZENKEVICH, L. A. *Fauna and Biological Productivity of the Seas*. 1947-49 (In Russian). V. I-II Sovetskaja Nauka, Leningrad, U.S.S.R.

Conferences and Meetings

Calendar *

1956/1957

November 19 to	South Pacific Fisheries Training Course	Noumea
February 24 1957	(sponsored jointly by the South Pacific Commission and FAO)	
January	FAO Regional Conference in the Near East	
	Central American Integration Scheme Committee	
"	14 Indian Science Congress - 44th Session	Calcutta
February	20 Training Course in the Dynamics of Fish Populations	Lowestoft (England)
May	Symposium on Techniques of Measuring Basic Marine Production	
	Caribbean Commission - 7th Session of the West Indian Conference	
"	7 International Hydrographic Bureau - 7th Congress	Monte Carlo
	10 Indo-Pacific Fisheries Council - 7th Session	Bandung
"	14 Permanent Commission of the International Fisheries Convention (1946)	London
"	20 International Commission of the North Atlantic Fisheries (ICNAF)	Lisbon
May/June	Workshop on Population Dynamics and the Selectivity of Fishing Gear (joint ICNAF/ICES/FAO)	Lisbon
June	1 Congress of International Committee on Photobiology	Turin
"	24 International Whaling Commission, 9th Annual Meeting	London
July	International Harbor Congress	London
	International Congress on Ship Hydrodynamics	Madrid
August	International Statistical Institute - 30th Meeting	Stockholm
	British Association for the Advancement of Science	Dublin
"	28 International Congress on Cell Biology - 9th Session	St. Andrew's (Scotland)
September	American Society of Limnology and Oceanography - Special Meeting	Woods Hole (U.S.A.)
"	27 International Fisheries Trade Fair - Second	Copenhagen
"	30 International Council for the Exploration of the Sea - 45th Meeting	Bergen
October	7 International Fishing Gear Congress 1957 (FAO)	Hamburg
November	FAO Conference - 9th Session	Rome
	Caribbean Fisheries Seminar - 3rd Biennial Meeting	
	Regional Conference on Sea Fisheries (CCTA)	Western Africa
	Inter-African Statistics Conference (CCTA)	Laurenço Marques
	International Internal Combustion Engine Congress	Zurich
"	18 Pacific Science Congress - 9th Session	Bangkok
	International Advisory Committee on Marine Sciences - 2nd Meeting	

*ED. NOTE. All dates are subject to revision.

International Commission for the Northwest Atlantic Fisheries (ICNAF)

The Sixth Annual Meeting of ICNAF took place at Dalhousie University in Halifax, Canada, from 11 to 15 June 1956. The session was opened by the Chairman, Captain T. de Almeida (Portugal) and addresses of welcome were given by the Premier of Nova Scotia, the Hon. Henry D. Hicks; the President of Dalhousie, Dr. J. A. Keir; and the Deputy Minister of Fisheries for Canada, Mr. George R. Clark. There were delegations from all member countries of the Commission, and observers represented the Federal Republic of Western Germany, the U.S.S.R., the International Council for the Exploration of the Sea (ICES), the Permanent Commission of the International Fisheries Convention (1946), the International North Pacific Fisheries Commission, the World Meteorological Organization (WMO), and FAO.

The only change in panel membership was the admission of Iceland to Panel 1 (see *FAO Fisheries Bulletin*, VIII (3): 148, 1955). The panels reviewed the research programs being carried out in each sub-area of the region, and proposed various improvements in sampling, reporting the tag recaptures and statistics of catch and effort, and related matters.

The French Commissioner reported difficulties that had arisen in connection with the mesh regulation proposed at the Fifth Annual Meeting. After trawling in deep water, a large catch could, when brought to the surface, burst the large meshed cod end by expansion of the fish. An *ad hoc* committee considered this problem and recommended that research should be undertaken to determine the consequences of using multiple cod ends and to find methods of strengthening the cod end without diminishing the selective effect of the gear.

Another *ad hoc* committee was appointed to deal with the proposal that the present exemption from the mesh regulation should be amended to allow certain vessels using small meshed gear to pursue mixed fishing and include up to 10% of regulated species in their annual catches.

Because neither of the present standing committees is alone fully competent to deal with matters such as those mentioned above, the next meeting of the Commission is to discuss whether future procedure should be by reference of individual matters to *ad hoc* committees, or whether a new standing committee should be established to deal with regulatory and enforcement questions.

The proceedings of the Standing Committee on Research and Statistics, which had begun several days before the Commission meeting opened, were dominated by consideration of the results of the interim meeting in Biarritz (see *FAO Fisheries Bulletin* IX. (2): 100, 1956). From these discussions emerged two important documents: "An Outline of Present Research and Present and

Long-range Needs for the Convention Area," and a general report of the Committee which combined the report of the Biarritz Meeting by the Chairman of that Committee with reports by special working parties on work for the International Geophysical Year, research on cod stocks, the standardization and mechanization of fish measurements, publications' policy, and collaboration with FAO on the world survey of aquatic resources. Most interesting lectures were given to the Committee by observers from Western Germany and the U.S.S.R. on research being carried out by their countries in the North Atlantic.

The Chairmen of the Committees on Research and Statistics and on Finance and Administration were re-elected for the year 1956/57. The next meeting of the Commission will begin in Lisbon on 20 May 1957 and will be followed by a nine-day "workshop" on the dynamics of fish populations and the selectivity of fishing gear. FAO, and other international commissions concerned with the North Atlantic, are to be invited to collaborate with ICNAF in the latter activity, and it is expected that the outcome will be a comprehensive review of the present status of these subjects and the techniques of measurement and analysis employed.

International Conference of Marine Biology

An International Conference on the Comparative Biology of Marine Species studies in Different Districts of their Area of Distribution, sponsored by the International Union of Biological Science (IUBS), was held from 27 June to 4 July, 1956, in the Biological Station of Roscoff, France.

The Conference was attended by about 40 participants and 30 observers representing 14 countries.

Technical sessions were held covering such subjects as life cycles, biometrics, ecology, paleoecology, behavior, genetics and physiology of marine organisms; summaries of about 30 contributions were presented and discussed.

The purpose of the Conference was to establish a program and methods of work for comparative study, in different latitudes, of biological factors determining the limits of distribution of marine organisms. Sessions on methods and organization were also held, during which international co-operation in the field was discussed.

Resolutions were adopted by the Conference recommending close international co-operation in the study of marine organisms. To implement such collaboration the organization of a committee was recommended. The Conference requested that IUBS, International Council of Scientific Unions (ICSU), the United Nations Educational, Scientific and Cultural Organization (UNESCO) and FAO should stimulate national agencies in the conduct of basic research in marine biology.

At the meeting H. Rosa Jr., of the Biology Branch of FAO, presented a "Note on Abundance and Distribution of Marine Organisms of Economic Importance," dealing with the work being carried out by FAO on the survey of living aquatic resources. The Conference received this note with interest and recommended that use should be made of the information being compiled by FAO on marine organisms.

International Meeting of Fish Processing Technologists

Improved methods of keeping fish in fresh condition and problems associated with the assessment of fish quality were the main subjects discussed at the International Meeting of Fish Processing Technologists, held at Rotterdam, the Netherlands, from 25 to 29 June 1956. Reports of working groups on chilled fish, fisheries products for tropical consumption and freezing fish in bulk, were also presented and discussed.

This international meeting was organized by FAO under the auspices of the FAO Committee on Fish Handling and Processing. Some 120 fishery technologists representing about 30 countries attended.

The discussions on keeping fish in a fresh condition revolved around the use of the chemical sodium nitrite and the antibiotic substances aureomycin and terramycin, all of which exert preservative action as bacteriostatic agents; and around improved methods for keeping fresh fish in chilled condition so that spoilage, which is delayed by chilling temperatures, is retarded to the maximum extent. In a number of technical papers, evidence was presented showing that when these materials are applied to fish in minute quantities, either by way of the ice used for chilling or in the form of dips prior to icing, the length of time that fish can be held in good condition can be extended by several days. Sodium nitrite is already used effectively and successfully in one country for this purpose. The application of the antibiotic materials, however, required further study and research before their general use for fish preservation is ready for approval by national public health authorities. The research that is required includes the finding of improved methods of incorporating the antibiotic material uniformly in ice during its manufacture, large-scale experiments under commercial conditions of operation, studies of the residuals of antibiotic materials remaining after the fish have been cooked, and study of the general public health aspects of the use of antibiotic substances for fish preservation.

More effective chilling methods which have been investigated and on which studies were reported at the meeting, include the use of chilled brine, chilled sea water and ice made from sea water. In some cases the results have already found practical application in certain canning factories, e.g., salmon, pilchard and her-

ring, where it is helpful to be able to hold excess quantities of these fish in a satisfactory condition for even short periods. The methods can be used on board fishing vessels at sea or in connection with shore operations. The successful application of the technique of making and using sea water ice is of particular significance for regions where fresh water is in short supply and therefore excessively costly.

In the assessment of fish quality, new and improved methods were discussed. The object of research in the field is to devise objective methods of testing which can be applied under commercial conditions. There was general agreement that greater use should be made of testing panels for the evaluation of quality and freshness.

The meeting had several practical results. Perhaps the most important for the fishing industry throughout the world was the clear expression of opinion of the experts that the time had come to carry experiments in the use of antibiotics from the laboratory to the commercial field. The experts felt that with the concurrence of governments and public health authorities, large-scale experiments should be conducted with fishing vessels, particularly those engaged in long distance fishing. This, it was felt, would establish the effectiveness of antibiotics in preserving the fresh condition of fish and would also enable appropriate authorities to study public health aspects of the use of antibiotic materials for fish preservation.

International Inland Fisheries Meeting

The International Inland Fisheries Meeting was convened by the Fisheries Division of FAO and representatives of Member Governments from 24 to 26 July 1956, in Helsinki, Finland, to consider whether it was necessary to initiate further international action to bring about an increase of food production from inland fisheries and improvement in the conditions of those who are engaged in inland fisheries industries.

The meeting was attended by delegations from 13 countries; official observers were present from four international organizations, and in addition 39 members of the International Limnological Association attended in a private capacity. Dr. D. B. Finn, Director of the Fisheries Division, was present and was assisted by Mr. Wm. A. Dill and Miss O. E. Zipfel of the Biology Branch, and by Mr. E. D. Le Cren, engaged as consultant for the meeting.

After discussing the extent to which inland fisheries are exploited at present and the factors limiting the exploitation, the meeting discussed at length the application of fisheries science to inland fisheries. This discussion led into an examination of the programs which should be developed to remove those disabilities limiting exploitation, and from this discussion emerged agreement

on the kinds of international action which should be taken to assist in the development of these programs for the improvement of inland fisheries. The meeting discussed in detail the ways in which such international action could be brought about and serviced and finally adopted the following resolution :

INTERNATIONAL INLAND FISHERIES MEETING, HELSINKI

24th to 26th July, 1956

FINAL RESOLUTION

26th July, 1956

The representatives of the Governments of Austria, Belgium, Denmark, Finland, France, Federal Republic of Germany, Iceland, Netherlands, Norway, Spain, Sweden, Switzerland and the United Kingdom, being members of the Food and Agriculture Organization, assembled at Helsinki during the days of the 24th to the 26th July, 1956, to consider the appropriateness of some form of joint action amongst themselves designed to promote the development and utilization of inland fisheries, and :

- having* determined that such action is desirable, and
- having* determined to co-operate with each other for this purpose, and
- having* explored various means of achieving this end, and
- being* convinced that they should establish amongst themselves a means of giving effect to this purpose,
- resolve* to request the Director-General of the Food and Agriculture Organization to establish a Standing Advisory Committee on the Inland Fisheries of the interested countries in Europe, members of FAO, composed of experts in this subject whose functions would be to advise him and its Member Governments on measures to be taken with reference to :
 - (1) the collection and dissemination of pertinent information,
 - (2) the organization of appropriate symposia,
 - (3) the establishment of proper liaison in co-operation with governmental and non-governmental organizations,
 - (4) the evolution of such an organized approach amongst interested governments of this region towards the development of inland fisheries as may seem desirable and feasible, and
 - (5) any other matters appropriate to the promotion of the development and utilization of the inland fisheries within the competence of the Organization.

2nd Symposium on African Hydrobiology and Inland Fisheries

The 2nd African Symposium on Hydrobiology and Inland Fisheries, convened by the Commission for Technical Co-operation South of the Sahara and its Scientific Council took place at Brazzaville in French Equatorial Africa from 3 to 13 July 1956. The meeting took place in the Palace of the High Council of French Equatorial Africa. It was opened by Mr. H. Bredo, Scientific Secretary of the Scientific Council. Mr. J. L. Lemasson (France) was elected chairman, and Mr. H. Bredo, vice-chairman. The meeting was declared officially open by the Secretary-General of French Equatorial Africa, Governor Cédile, in the name of the Governor General, M. Chauvet, High Commissioner for the French Government.

The opening session was followed by ten sessions of work, and the meeting proper was terminated by a closing session on the afternoon of Tuesday, 10 July. During this period, there also took place a number of tours and excursions. These included visits to the Institut d'études centres africains (IEC), the fish-farming station of the Djoumouna and to the Kinkala district where African farms and domestic ponds were seen. In addition, a visit was paid to the fish market at Léopoldville and to the Kingabwa fishing station. After the closure of the meeting proper, excursions were made to institutions at Pointe Noire, in particular to the Centre océanographique.

The meeting was attended by representatives from British East Africa, Nigeria, the Federation of Rhodesia and Nyassaland, Union of South Africa, Portugal, Mozambique, Belgium, Belgian Congo, France, French Equatorial Africa, French West Africa, Madagascar, Togo, Cameroons, and FAO.

The agenda consisted of three principal items, the first dealing with fisheries in natural and open waters, the second with fish farming and the third with products of fishing and fish farming. Under the first item there were discussions of hydrobiology of lakes and rivers, research on fish of economic value, on the propriety of attempting to introduce a fully pelagic fish into Lake Nyassa with the object of utilizing the deep water, the present situation of fisheries from the biological, technical, social and economic aspects, the organization and development of fisheries in natural waters and the organization of fishing in artificial reservoirs. Under the second item, there was discussion on research on fish that may present a value for fish farming, on artificial lakes, on the fishery potentialities of Kariba Lake, on the culture of *Tilapia* species and on the methods of fish farming these species, on methods of fish farming of species other than *Tilapia*, on fish farming in rice paddies and on action for the development of fish farming. A long list of papers exceeding 80 in number was presented to this agenda.

The meeting adopted a number of recommendations and conclusions dealing with such matters as further research work to be

undertaken and the problem of the effect of DDT on aquatic fauna, on the problem of water hyacinths (*Eichornia*), on the methods of promoting familial fish culture, on the introduction of exotic species, on the importance of the collection of statistics and on further international collaboration. It was recommended that the next symposium should take place in 1959, preferably in one of the territories of the Federation of Rhodesia and Nyassaland or in the Union of South Africa.

International Whaling Commission (IWC)

The 8th annual meeting of the IWC took place in London from 16 to 20 July 1956. The meeting was opened by the Chairman of the Commission, Dr. G. J. Lienesch (Netherlands). An address of welcome was given by Mr. G. R. H. Nugent, M. P., Parliamentary Secretary of the Ministry of Agriculture, Fisheries and Food. All 17 contracting governments were represented at the meeting, with the exception of Brazil. Italy and Portugal were represented by observers, as also were FAO, the International Council for the Exploration of the Sea (ICES) and the International Association of Whaling Companies.

The Commission received from the Bureau of International Whaling Statistics data on the operations and the catch for the past season. These data showed that 19 factory ships with 257 catchers had been engaged in the 1955/56 Antarctic season, to take a total catch yielding 2,134,012 barrels of oil, including sperm oil.

The Commission received various scientific papers concerning the stocks of whales and scientific opinion in the Commission was almost unanimously in favor of a substantial reduction in the catch in view of evidence that the stock is declining. The Commission recommended that the catch for future seasons should not exceed 15,000 blue whale units, which is the existing limit and, with one dissentient, recommended that the limit should be reduced in the coming season, 1956/57, to 14,500 blue whale units.

The Commission examined the returns which had been rendered in respect of infractions of the whaling regulations and was glad to note that, in general, there was a decrease over the previous year. The Commission also received further confirmation from the Commissioner of the U.S.S.R. of the use of fenders of porous rubber to replace the present use of whale carcasses for this purpose. The U.S.S.R. agreed to place at the disposal of the Commission full details of these fenders.

The Commission allocated £ 500 (U.S. \$ 1,400) towards the cost of whale marking.

At present every factory ship is required to have on board two inspectors who are generally of the same nationality as the flag of the ship. However, the Commission had asked the U.S.A.

to prepare a protocol for the amendment of the convention, to permit consideration of a scheme to appoint independent observers in addition to the national inspectors. Every effort is being made to bring the protocol into force in time for the Commission to take action under its provisions at the 9th meeting.

The annual meeting for 1957 will begin on 24 June 1957 in London.

Thirteenth Limnological Congress

About 400 participants from 35 nations met in Finland for the Thirteenth Congress of the International Association of Theoretical and Applied Limnology which took place from 27 July to 7 August 1956. At the lecture meetings, held in Helsinki between 27 July and 2 August, 117 papers were delivered on the typology of lakes, brackish water problems and osmoregulation, the pollution of lakes and rivers by the pulp industry, toxic effects of industrial pollution, problems of the inland fisheries, the limnology of areas outside Europe, plankton, and miscellaneous zoological, botanical and hydrobiological questions.

Dr. W. E. Ricker (Canada) delivered the Edgardo Baldi Memorial lecture on "Production, Reproduction and Yield." A special session of the Methods Committee was dedicated mainly to questions of quantitative plankton research.

The following films were shown :

- E. Siltamaa (Finland) : Winter Seining in Southwest Finland
- E. Fabricius (Sweden) : The Spawning Behavior of the Char and Grayling
- G. Nygaard (Denmark) : On the Productivity of the Bottom Vegetation of Grane Langsø
- K. Stundl (Austria) : Pollution of the Waters in Steyermark

The Finnish research vessel *Aranda* made numerous demonstration trips with the participants.

From 3 to 7 August, Congress excursions brought participants to the lake area in Central Finland through Lahti-Kuhmoinen-Mänttä-Tampere-Aulanko up to Ekenäs and through the Skerries to the Zoological Station in Tvärminne.

At the concluding meeting in Helsinki on 7 August, Professor U. d'Ancona (Italy) was elected President of the International Limnological Association, replacing the late Mr. F. E. Fritsch (Great Britain).

A resolution was passed demanding energetic measures against the increasing pollution of inland waters. This resolution will be distributed to all governments. Furthermore, a special committee on pollution questions will be formed, for which every Member Government should select a delegate.

On 7 August, a great post-Congress excursion started, which led through East Karelia to Joensuu-Nurmes and further to Oulu-Tornio-Pallastunturi and and Kilpisjärvi, where it ended on 16 August.

Thanks to the admirable preparations by the Finnish Organizing Committee for the Congress, under the leadership of Professor H. Järnefelt, Chairman, and Dr. H. Luther, Secretary, the excursions offered abundant opportunity for field study of streams and lakes, problems of water pollution and inland fishery questions.

The next Congress will be held in Austria in 1959.

Fisheries Division Activities

Headquarters

A letter, together with a proposed agenda, has been sent out to Member Governments and a selected list of interested industrial organizations announcing the First International Fishing Gear Congress being organized by FAO to take place in Hamburg, in Western Germany, in October, 1957.

Preliminary returns from this announcement indicate that there is widespread interest in the Congress and all comments so far received are very much in favor of it taking place.

It is anticipated that the Congress will be attended by representatives of governments and of the fishing industry in all parts of the world and that a great number of papers will be presented at the meeting, dealing with all the most important aspects of fishing gear at present used and with likely developments in the near future. It is hoped that the Technology Branch of Fisheries Division, which is primarily responsible for organizing the Congress, will also be able to publish a *Manual of Fishing Gear* in time for the Congress.

The Fourth Meeting of the General Fisheries Council for the Mediterranean (GFCM) was held at Istanbul, from 17 to 22 September, and was attended by about 50 representatives from member countries as well as by observers from non-member countries and organizations. More than 40 papers were presented. A report of the Meeting will be published in the next issue of the *FAO Fisheries Bulletin*.

The South Pacific Fisheries Training Course, jointly sponsored and organized by the South Pacific Commission and FAO, opens on 19 November 1956 and continues until 24 February 1957. The 14-week course is being attended by fishery officers from countries in the areas of the South Pacific Commission and Indo-Pacific Fisheries

Council. The curricula includes lectures and seminars covering fisheries technology, biology and economics. Participants will study a wide variety of fisheries problems, such as the life and habits of commercial species of fish in the Pacific waters, methods and gear used in catching the fish, boats and equipment, the principles of fish processing — smoking, marinating, salting, sun drying, etc. — management practices, fishermen's co-operatives and distribution and selling of fresh and processed fish and fish products.

A report on the Numea Training Course will be published in a later issue of the *FAO Fisheries Bulletin*.

Pierre Chimits (France), inland fisheries biologist, who returned to his former post with the Eaux et Forêts section of the French Ministry of Agriculture at the end of June.

Mr. J. Alan Tubb, who carried out a survey of the inland fisheries resources in Burma on behalf of FAO during the past year, has been appointed Regional Fisheries Officer for the Indo-Pacific area. He took up his new duties at the Headquarters of the Regional FAO Office, Bangkok, in August.

Mr. Tubb, who is an Australian from Hawthorn, Victoria, has had considerable experience as a fishery biologist in the Far East. After leaving the University of Melbourne, he worked as a fishery biologist for the Commonwealth Scientific and Industrial Research Organization. In 1946, he was attached to the Fisheries Division of the Supreme Command for the Allied Powers in Japan. From 1947 to 1952 he was Director of Fisheries in North Borneo and from 1953 to 1954 Reader in Marine Biology in the University of Hong Kong.

Mr. Remy Freire, Assistant Regional Fisheries Officer for Latin America, is spending six months at Headquarters.

Regional and Field Work

Finn Devold, Chief of Herring Investigations, Directorate of Fisheries, Bergen, Norway, was at Headquarters for briefing before taking up his one-year assignment as marine fisheries biologist in *Brazil*. He is advising and assisting the Government in surveying and appraising marine fisheries resources, and in the planning and carrying out of field and laboratory work, necessary for the implementation of the program. He is especially studying the sardine resources of the central coast of Brazil, and the possibilities of expanding the trawl fisheries of the central and southern coast of the country.

John Fridthjof (Denmark) went to *Brazil* in June, where he is advising and assisting the Government on the improvement of fish marketing in the southern states of the country, to enable the local fisheries industries to achieve a more rational and economic distribution of fish supplies.

Charles Georges Salmon, (France) whose permanent post is in charge of the Fisheries Administration in the district of Vannes,

has taken up a twelve months' assignment with the *Caribbean Commission* as fishery economist. After briefing in Headquarters in Rome, he left to take up his new appointment early in September. His duties are to advise and assist the Government of the territories of the Member Governments of the Commission on: (a) the increase of fish; (b) the development of local fish marketing, including preservation; (c) government fishery administration, and (d) the need for any additional specialized technical assistance in these fields.

Mr. Salmon was formerly in charge of fisheries in other parts of France and in French North Africa.

On his return from Home Leave, J. Saemundson (Iceland), master fisherman, stayed at Headquarters for a few days before returning to his assignment in *Ceylon*.

Chr. Eriksen of Dansk Andelsfisk of Copenhagen, Denmark, left in August for *Jordan*, on a four months' assignment as fishery technologist. He is stationed at Aquaba, and his work is mainly concerned with the operation of the cold storage plant there, and refrigerated transport from the plant to Amman in the interior.

Jean Gaullièrre (France) left for the *Lebanon* in August to take up his short-term assignment there as fishery economist. He is making a general survey of fish production and trade in the country, and advising the Government on a suitable development policy and the setting up of appropriate services and administrative machinery for its execution.

Tatsuzu Suzuki (Japan), master fisherman, has gone to the *Philippines*, to take up his twelve months' appointment. He will assist in the conduct of experimental fishing for tuna and other pelagic species, mainly with floating long lines on the high seas.

Erling O. Oswald from Juneau, Alaska, has taken up a twelve months' assignment in the *Sudan* as master fisherman. His duties are to advise and assist the Government in improving and mechanizing local fishing boats and fishing methods and introducing new methods suitable for local conditions.

Mr. Oswald has had much experience in the handling of small fishing boats. He is the son of a fisherman and went to sea in his father's boat when he was a boy. After two years in the U.S. Navy, he studied for two years in universities, and then took up fishing for halibut and black cod off the Alaskan coast in spring and for albacore off the coast of California and Mexico from August to December. In 1954, he took a 48-ft. seine type of boat from the west coast of the U.S.A. to Honolulu for commercial fishing of tuna in the waters off Christmas Island. Later he joined the U.S. Fish and Wildlife Service and has been working out of Honolulu for the Pacific Oceanic Fisheries Investigations for the past two years.

Luigi Farina (Italy), master fisherman, has gone on his second short-term assignment to *Syria*, where he is conducting experimental deep sea trawling.

H. I. Chapelle (U.S.A.), naval architect, has taken up a twelve months' assignment in *Turkey*, where he is advising and assisting the Government on problems regarding the mechanization of available fishingcraft and on the design of improved mechanized fishing and transporting craft to suit local fishing conditions, and which can be built in local boatyards.

Clifford Petersen (U.S.A.) formerly of the Inter-American Tropical Tuna Commission, La Jolla, California, U.S.A., has taken up a year's assignment in *Venezuela* as marine fishery biologist. His duties are to advise and assist in operations to determine the presence of stocks of clupeoids in Venezuelan waters, to determine the distribution of these stocks, and to measure their abundance.

Among experts who have recently completed assignments are the following :

Knud Frederiksen of Kirke-Hyllinge, Denmark, who for the past year has been on an assignment in *Iran*, where he advised and assisted the Government in the conduct of a program of exploration with modern fishingcraft, gear and methods.

E. Tengberg-Hansen (Denmark), completed his final report on his six months' assignment to *Israel* as fish canning technologist and has returned to Denmark.

F. L. Bourgois (France), fisheries specialist, who returned to FAO Headquarters to write a report of his assignment in *Libya* where he advised and assisted the Government in the formulation of a fishery policy.

W. H. Schuster (Netherlands) has completed his short-term assignment in *Nicaragua*, *Honduras* and *Guatemala* and has reported on his reconnaissance survey of inland fisheries.

Olav Aasen (Norway), who spent two years in *Turkey* as fishery biologist, has prepared a final report and has returned to his former work at the Norwegian Fishery Research Station in Bergen.

A. A. Dawson (U.K.), well-known fishery economist, returned home after writing the report on his assignment in *Turkey*.

I. S. McArthur (Canada) returned to Headquarters in June to report on his short-term assignment in *Turkey* as fisheries consultant before going back to Canada.

Viga Rivas (Mexico) left Headquarters to continue his fellowship studies in fishery statistics in administration in Italy, France, Spain and Portugal, and J. Galea (Malta) who has been studying fishing gear and methods at Headquarters, completed his three months' fellowship in August and returned home.

Current Fisheries Literature

A New Serial Publication of Interest to Fisheries Workers

The following announcement appeared in a new quarterly journal published by the American Society of Limnology and Oceanography :

The Society has established *Limnology and Oceanography* in response to a need felt by its members for a common outlet for the publication of scientific papers on all aspects — physical, chemical, geological and biological — of the phenomena exhibited by natural bodies of water.

The Society was organized in St. Louis on 1 January 1936 as the Limnological Society of America. It had become apparent at that time that interest in fresh-water biology and the physical factors which control the fresh-water environment had grown to a point where a separate organization was needed to encourage scientific work in this aspect of ecology. Just as it had been accepted from the start that students of the biological, chemical and physical aspects of limnology had much to gain by association, so it was soon realized that the differences between fresh and salt water systems were trivial, when compared to the common principles with which limnologists and oceanographers alike are concerned. In 1948, the organization was renamed the American Society of Limnology and Oceanography and physical oceanographers and marine biologists assumed their share in the privileges and responsibilities of membership.

Limnology and Oceanography is offered now to all those concerned with aquatic sciences, both in this country and abroad, in the faith that it will serve a useful purpose by providing a common medium for technical papers on the varied specialities which unite to increase our understanding of the aquatic environment.

The editor is D. G. Frey (Indiana University, Bloomington, Indiana, U.S.A.), and the first issues contain the following papers :

Vol. 1 (1), January 1956.

PRATT, D. M., and CAMPBELL, D. A. "Environmental Factors affecting Growth in *Venus mercenaria*."

RAWSON, D. S. "Algal Indicators of Trophic Lake Types."

AYERS, J. C. "Population Dynamics of the Marine Clam, *Mya arenaria*."

EMERY, K. O. "Deep Standing Internal Waves in California Basins."

BRYSON, R. A., and BUNGE, W. W., JR. "The Stress-Drop Jet in Lake Mendota."

EDMONDSON, W. T., ANDERSON, G. C. and PETERSON, D. R. "Artificial Eutrophication of Lake Washington."

POMEROY, L. R., HASKIN, H. H., and RAGOTZKIE, R. A. "Observations on Dinoflagellate Blooms."

RYTHER, J. H. "Photosynthesis in the Ocean as a Function of Light Intensity."

Vol. 1 (2), April 1956.

A Symposium on Primary Production.

FREY, D. G. Preface.

RYTHER, JOHN H. "The Measurement of Primary Production."

VERDUIN JACOB. "Primary Production in Lakes."

PENFOUND, W. T. "Primary Production of Vascular Aquatic Plants."

ODUM, H. T. "Primary Production in Flowing Waters."

RAVERA, OSCAR and TONOLLI, VITTORIO. "Body Size and Number of Eggs of Diptomids, as Related to Water Renewed in Mountain Lakes."

RICE, T. R. "The Accumulation and Exchange of Strontium by Marine Plankton Algae."

Subscription rate for libraries and non-members of the Society is U.S. \$10.00 per year, payable to Mr. B. H. Ketchum, Secretary/Treasurer, American Society of Limnology and Oceanography, at the Business Office, Woods Hole Oceanographic Institution, Massachusetts, U.S.A.

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A New Series of Scientific Publications in Fisheries

The Fishery Laboratory recently established by the Government of Turkey at Besiktas, Istanbul (see *FAO Fisheries Bulletin*, VIII (3): 165, 1955) has begun issuance this year of a series entitled *Et ve Balık Kurumu, Balıkçılık Araştırma Merkezi Raporları* [Reports from the Fishery Research Center, Meat and Fish Office]. Series: Marine Research. The reports so far printed (see list below) deal mainly with the results of cruises by the R/S *Arar*, and give data on hydrographic factors, plankton, statistics and sampling, fish location by Asdic, and gear trials in the Black Sea, Bosphorus, Sea of Marmara and the Eastern Mediterranean. Most of the work reported has been carried out with the help of an FAO expert, Mr. Olav Aasen, under the Expanded Technical Assistance Program. An introductory report is being prepared, and numbers 6, 7 and 8 of the series will deal with cruises in the Black Sea to study the stocks of anchovy and turbot. The papers are in English, with summaries in Turkish; the Meat and Fish Office will welcome an exchange of publications with other institutions.

No. 1. AASEN, Olav and ARTUZ, I. "Some Observations on the Hydrography and Occurrence of Fish off the Turkish Black Sea Coast, 11 October - 1 November 1954."

2. ———, and AKYUZ, E. "A Contribution to the Fishery Investigations in the Sea of Marmara."

3. ———. "The Lampara Net in Turkish Waters."

4. AASEN, OLAV and AKYUZ, E. "Some Data concerning the Fisheries in Iskenderum Bay."

5. AASEN, OLAV, ARTUZ, I, and AKYUZ, E. "Report on a Survey of the Turkish Black Sea Coast."

Selected Publications Received

UNITED NATIONS. *Papirs presented at the International Technical Conference on the Conservation of the Living Resources of the Sea, Rome, 18 April to 10 May 1955.* United Nations, New York. Sales No. 1956. II. B. 1. xii - 371 pp. Price: U.S. \$3.00., 22s. 6d., Sw. Fr. 13.00. (For a report on the Conference, see *FAO Fisheries Bulletin*, VIII (3) : 117-30).

LUDORFF, W., and KREUZER, R. *Der Fisch vom Fang bis zum Verbrauch* 1956 [Fish from Catch to Consumption]. Verlag Carl Th. Görg, Bremerhaven, Western Germany. 98 pp., illus., bibl. In German.

This booklet, prepared by the German State Research Organization for Fisheries, deals with handling fish after they are caught to the time they are sold to the consumer. Topics discussed include handling of fish in the fish hold, unloading, cutting and cleaning, transport and packaging, disinfectants and disinfection, wholesale and retail markets.

NAZIR AHMAD. *Fish Markets of East Pakistan and the Question of their Improvement.* Government of East Bengal. Directorate of Fisheries, Dacca. 11 pp., plates.

HONG KONG. *Annual Departmental Reports 1954-1955.* Registrar of 1956 Co-operative Societies and Director of Marketing. 39 pp., tables. Price: Hong Kong \$ 3.00.

This document is divided into four sections : 1. Co-operative Societies ;
2. Fish Marketing Organization. 3. Vegetable Marketing Organization.
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